QUEENSLAND INSECT PESTS AND THEIR CONTROL

VEITCH

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by

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Introduction

This first part of the third volume of the Queensland Agricultural and Pastoral Handbook discusses the control measures which may be employed against the more important Queensland insects attacking crops other than sugar-cane. Attention is devoted mainly to a simply worded outline of these control measures, but it has also been considered desirable to give a brief account of the life histories of the various pests and of the nature of the damage inflicted by them. The accompanying short descriptions of the insects should assist the reader in identifying the pests, which is rather important, because the intelligent application of control measures is generally impossible without that accurate identification which immediately makes available some definite knowledge of the rudiments of the life history of the insect to be controlled.

Although the main feature in this discussion is naturally the control of plant-feeding insects, household pests of importance to the primary producer are dealt with in the final chapter.

Should a reader require further information regarding any of the insects discussed herein or concerning pests which have not received mention, he is advised to get in touch with the nearest field officer of the Department. He can also communicate with the Department of Agriculture and Stock, William Street, Brisbane, or with one of the entomological field stations which are located at Atherton, Rockhampton, Biloela, Nambour, Toowoomba, and Stanthorpe. Communications should be addressed to the nearest field officer or entomological field station in order to obtain a reply at the earliest possible moment and should be accompanied by specimens of the insect concerned and by small samples of the damage associated with its presence. Specimens are desirable in order to eliminate any doubt as to the identity of the pest, because the type of injury complained of may be inflicted by any one of several insects, each of which may require the application of a different set of control measures.

Officers of the Department of Agriculture and Stock have prepared an extensive series of advisory leaflets, pamphlets, and bulletins dealing with plant pests, and copies of these are available free on application by readers who desire to supplement the information contained herein.

It has been considered expedient to divide this part into chapters dealing with the following subjects:—(1) *Insecticides,* (2) *Fruit Pests,* (3) *Agricultural and Grassland Pests,* (4) *Vegetable Pests,* (5) *General and Household Pests. The whole of this text has been specially written for this handbook, but a few pages have already been published in the "Queensland Agricultural Journal" in order to supply urgently required information.*

Contents

Chapter I.—INSECTICIDES.

THE function of insecticides is to kill the insect pest without inflicting appreciable injury to the insect's host, whether it be plant or animal. Insecticides used to eliminate insect infestation in manufactured goods or stored products must also be capable of being employed with a similar degree of safety to the treated article. Furthermore, the cost of the chemical and its mode of application must be such as to render its use economically practicable. It is also essential that the insecticide be applicable with a reasonable degree of safety to the operator, and finally it must not leave spray residues likely to be injurious to the subsequent consumer or user of the treated plant tissue, foodstuff or manufactured article.

Insecticides are usually classified as stomach poisons, contact insecticides, and fumigants. The stomach poisons are employed against insects which bite off and swallow portions of the plant on which they are feeding. Contact insecticides, on the other hand, are used mainly for the control of insects which feed by piercing the skin of the host plant and sucking the sap from the underlying tissue. Fumigants may be employed against both the biting and sucking type of insect.

It is not intended to discuss all the insecticides that are available, but rather to indicate the characteristics and uses of the more generally employed materials.

ARSENATE OF LEAD.

Arsenate of lead has for many years held pride of place as the most suitable form in which to apply arsenic as a stomach poison for the control of insect pests that feed by chewing. It remains in suspension in a spraying mixture reasonably well; it does not readily burn the foliage of treated plants, and it generally kills quite satisfactorily. It can be used with safety for the control of a number of important insect pests, but it must not be employed in such a manner as to leave injurious quantities of spray residue on the portions of plants intended as food for man or beast, because both the arsenic and the lead in this spray are highly poisonous.

This insecticide can be purchased either as a powder or a paste, and if obtained in the powder form, the purchaser must make sure that every particle of the powder is well moistened before being added to the water when the spray is being prepared. The best procedure is to gradually add small quantities of water to the powder until a thin paste, free from lumps, is obtained. This paste can then be thinned further and finally added to the water required to make up the desired strength of spray, the spray being thoroughly agitated while being applied.

Various strengths of arsenate of lead spray are used, one of the commonest and most satisfactory formulae being arsenate of lead powder 1½ lb. and water 50 gallons. When the arsenate of lead has been purchased in the paste form, then 3 lb. must be used to 50 gallons of water.

Arsenate of lead may be combined with Bordeaux mixture in cases where the grower desires to control chewing insects and certain fungous diseases by a single application of a combination spray. The best procedure in such a case is to prepare the Bordeaux mixture in the

usual manner and to add to it the required amount of arsenate of lead, the addition to the Bordeaux mixture taking place in the spray tank, the agitator of which should be kept running while the arsenate of lead is being added. In computing the amount of arsenate of lead required the Bordeaux mixture should be regarded as being the equivalent of an equal number of gallons of water.

Arsenate of lead and nicotine sulphate also form a useful combination in cases where a single application is required for the control of chewing insects and certain species of sucking insects. The soap usually employed in the preparation of a nicotine sulphate spray must, however, be omitted in this case because its presence in the combined spray would lead to the production of water-soluble arsenic with consequent spray injury. As a substitute for the soap, hydrated lime has been recommended at the rate of 2½ lb. to 50 gallons of the spray mixture. The hydrated lime will serve to liberate the nicotine from the nicotine sulphate, a reaction that is so essential to the successful application of a spray containing nicotine sulphate.

A third combination in which arsenate of lead sometimes features is an arsenate of lead and oil spray. This combination possesses certain disadvantages, the chief of which is that the presence of the oil renders an arsenate of lead residue difficult of removal and the spray residue problem in marketed fruit is correspondingly accentuated. Furthermore, the combination in the case of certain oils may lead to the liberation of water-soluble arsenic, the presence of which will cause spray injury.

Lime sulphur and arsenate of lead is a frequent combination for the control of certain fungous diseases and insect pests in deciduous fruit orchards. Spray injury may, however, follow on the production of water-soluble arsenic, formed, presumably, as a result of the interaction between the lime sulphur and arsenate of lead. To obviate such a possibility the addition of hydrated lime has been recommended at the rate of 2 lb. of hydrated lime to each 1 lb. of arsenate of lead, this mixture being worked into a paste with water and added slowly to the lime sulphur in the spray tank, the agitator of which is kept running. It is further recommended that no delay should occur in the application of this spray once it has been prepared. The arsenate of lead and lime sulphur spray is also sometimes used in citrus orchards, generally for the control of Maori mite or red spider and some chewing insect, although occasionally the lime sulphur is included in the combination in order to control certain scale insects.

Arsenate of lead is also used very extensively as a dust, several good proprietary lines, containing the arsenate of lead at strengths ranging from 14 per cent. to 70 per cent. being on the market. A convenient carrier for the dilution of arsenate of lead in the preparation of a dust is hydrated lime, and any farmer desiring to make up his own dust may do so by thoroughly mixing the correct quantities of the two ingredients; e.g., a 25 per cent arsenate of lead dust may be prepared by mixing one part by weight of arsenate of lead with three parts of hydrated lime. Mixing must be thorough and may be conveniently accomplished by vigorously rotating a sound box or barrel partly filled with the ingredients to which several large round stones have been added.

CALCIUM ARSENATE.

Calcium arsenate is an arsenical which is now frequently employed overseas for dusting purposes, particularly for the control of cotton pests. It is not quite such a stable compound as arsenate of lead, and it is generally considered that it should be used only when fresh supplies are available. It has not yet entered into common use in Queensland, and its further discussion is at present unnecessary; it may, however, become more extensively used in this State in future.

CUTWORM BRAN BAIT.

An excellent form in which to use an arsenical insecticide is obtained by incorporating Paris green in a mixture of bran, molasses, and water. The bait thus prepared is very attractive to cutworms and army worms, and effectively deals with these pests in a wide range of field crops including cotton, tobacco, and tomato.

Paris green was formerly used as an arsenical spray, but for that purpose it has been almost entirely displaced by arsenate of lead, which is not so liable to burn foliage and which, moreover, remains in suspension much better than most commercial grades of Paris green. The latter insecticide, however, is more toxic, and is accordingly used in the preparation of bran bait for cutworm control, because in the case of bait placed on the ground the factors which render Paris green unsatisfactory in a spray are of no consequence.

The bait may be prepared by thoroughly mixing 25 lb. of bran and 1 lb. of Paris green while still dry. Molasses to the extent of 3 or 4 lb. is then mixed with water, and this is added to the dry bran and Paris green, the whole being well mixed, care being taken to ensure that only enough water is used to obtain the right consistency. It will generally be found that only 2 gallons of water is required to produce the desired consistency for the quantity of bran mentioned. The bait should be crumbly and not over-moist, thus permitting it to trickle through the fingers.

As a precautionary measure poultry should not have access to a field in which bran bait has recently been scattered; any tendency to danger, however, is largely dependent on the method and density of bait distribution. All domestic animals should be kept away from the containers in which the bait has been prepared until these have been emptied and thoroughly cleansed.

The method of applying bran bait and the quantities required per acre will be found fully discussed in the measures recommended for the control of the brown cutworm on page 55.

GRASSHOPPER BRAN BAIT.

A different type of bait is employed for the control of grasshoppers, the arsenical in this case being arsenic pentoxide, a favourite in Queensland because of its frequent availability on the station or farm. The formula for this bait is arsenic pentoxide ½ lb., molasses 4 lb., bran 25 lb., water 2½ gallons. The molasses in this formula may be increased to 6 lb. in dry districts particularly if a plentiful supply is available. The arsenical is dissolved in a pint of boiling water in a kerosene tin or other container of suitable size, the molasses being similarly mixed with the same quantity of boiling water in a second container. Both the solutions are thoroughly stirred and half the balance of the water, i.e., 1⅛ gallons, is added cold to each container,

the solutions being again well stirred. The next step is to add the molasses solution to the arsenical solution, this being accompanied by further stirring. The bran is then spread on a mixing board or sheet of iron and the arsenic and molasses solution is added to the bran, the whole being thoroughly worked up until a moist loose mash is obtained, the consistency of the mash being such as to permit of its trickling readily through the fingers.

The mixing of this bait should not be done by hand, and tin scoops or other implements should be used for manipulating the arsenic. A wise precaution consists of smearing the hands with petroleum jelly before preparing and broadcasting the bait, the hands being thoroughly washed after the work has been completed. The precautions with respect to domestic animals mentioned in the discussion of the cutworm bran bait should also be observed in the case of the grasshopper bran bait. The manner of application of this bait is fully discussed in the paragraphs dealing with plague grasshopper control on page 57.

SWABBING MIXTURE.

A swabbing mixture which may be employed in cotton fields for the control of pests such as the corn ear worm and the cotton web-spinner is prepared by mixing 1 lb. of arsenate of lead and 1 gallon of molasses with 6 gallons of water. Its mode of application is discussed when considering the control of the cotton pests, just mentioned.

SODIUM FLUORIDE.

An insecticide of minor importance is sodium fluoride which acts mainly as a stomach poison although it is believed to possess some slight value as a contact insecticide. It has been suggested as a substitute for arsenicals in baits prepared for the control of cutworms and grasshoppers, but its chief use in insect control is in the destruction of cockroaches. It is somewhat poisonous to human beings and must therefore be used with discretion in dwelling houses. Various proprietary insect powders having sodium fluoride as the active principle are on the market.

SILVERFISH BAIT.

A recently introduced silverfish bait which has proved successful in Australia is prepared according to the formula 1 oz. flour, $1\frac{1}{2}$ oz. sugar, 10 fluid oz. water, $\frac{1}{4}$ oz. barium fluosilicate or $\frac{1}{8}$ oz. zinc borate. The flour, sugar and water are heated to form a warm paste to which the poison is added, the mixture being then spread on small strips of white cardboard. Discretion should be exercised in the use of this bait on account of the poison which it contains.

BARIUM CARBONATE.

Barium carbonate is a poison very frequently employed in the preparation of bait for the control of rats and mice. It is cheap and effective and is generally used in the form of a biscuit prepared by mixing one part by weight of barium carbonate with three parts of flour. These ingredients are mixed together, sufficient water being added to enable a stiff dough to be prepared. This dough is then rolled out to the thickness of a quarter of an inch and is cut up into pieces half an inch square. Finally these small biscuits are dried in the sun or in an oven and are then ready for use. Although much less dangerous than most other poisons employed in rodent bait, barium carbonate biscuits must nevertheless be handled with care and should not be placed within reach of domestic animals or children.

RED SQUILL.

Another rat poison is obtained from the fleshy bulbs of a wild plant growing on the shores of the Mediterranean Sea. This plant is known as the red squill or sea leek and it provides an efficient rodent poison which is readily eaten by rats and mice. Red squill can be obtained as a powder or as a liquid, such substances as fish, steak, bran, and oatmeal being used in the preparation of the bait. A commonly employed bait is obtained by mixing 1 oz. of powdered red squill with sufficient water to produce a thin paste which is added to and well mixed with 1 lb. of fresh finely chopped up meat. Another formula is 1 oz. of powdered red squill and 1 lb. of oatmeal, bran, or some other cereal meal, the ingredients being mixed dry and then moistened by the addition of a pint of milk or water. A third form of bait is obtained by cutting $\frac{1}{2}$ lb. of bread into $\frac{1}{2}$-inch cubes and mixing it with a pint of liquid red squill. Red squill varies in toxicity, and the formulæ just quoted are based on the assumption that the red squill used in the preparation of the bait is of high toxicity. Although red squill is the safest material to use in rodent control it should be used with discretion in its application.

RESIN–CAUSTIC SODA–FISH OIL.

A departmental spray prepared according to the following formula has recently been evolved for use against the bronze orange bug and other citrus pests, more particularly scale insects:—10 lb. resin, 3 lb. caustic soda of good commercial quality, $1\frac{1}{2}$ lb. herring or other fish oil, and 40 gallons of water.

The resin should be finely ground up before commencing operations, the next step being to dissolve the caustic soda in 2 gallons of water, to which the resin is slowly added while the mixture is boiling quietly. The mixture should be stirred during boiling to prevent solids adhering to the container. A creamy coloured scum forms on the surface of the mixture, the boiling of which should continue until a clear dark solution can be detected beneath the surface scum. The herring oil is added to this solution, and the whole mixture is then boiled for a few more minutes to make sure that no free oil is left. This quantity of concentrate is then available for dilution with 38 gallons of cold water. In preparing the concentrate, it is well to remember that the gently boiling solution expands, and therefore the selected container should be only half full if boiling over is to be avoided.

It will be noticed that a large quantity of solid matter is deposited as the concentrate cools off, hence if the concentrate is being prepared on a large scale necessitating its division into lots for subsequent dilution, it is suggested that the division be made while the concentrate is still hot. If divided into 2-gallon or $3\frac{3}{4}$-gallon lots, there will be sufficient concentrate in each lot to make up the 40 gallons or 75 gallons respectively, which represent the capacity of most Queensland spray tanks.

This concentrate cannot be kept satisfactorily except in airtight containers, and when such are not available the fish oil should not be added if the grower desires to store the concentrate. In such a case the concentrate should be prepared as directed except that the fish oil should be omitted for the time being. This modified concentrate is then stored and reheated when required, the herring oil being added at reheating and boiled as before for a few minutes to ensure that no free oil is left.

This spray must be carefully prepared, and it is essential that the clear, dark liquid be obtained as described. It can be applied with safety except during very hot weather, and its application should cease when the temperature exceeds 90°F. When the spray is being applied the agitator should be kept running. Smearing the hands with petroleum jelly is a procedure that should be adopted before preparing the resin-caustic soda-fish oil spray.

OIL SPRAYS.

Oil sprays have practically eliminated such old favourites as kerosene emulsion, and reliable proprietary brands of these sprays are now available at most orcharding centres in Queensland.

The proprietary oil sprays marketed in Queensland are obtained by selecting petroleum oils in various stages of refinement and adding either soap alone or soap in combination with some other substance, the objective in both cases being to facilitate the formation of a stable emulsion when mixed with water. Earlier spraying oils were known as red oils, but in recent years the so-called white oils have largely displaced the red oils. There is not so much to choose between the red oils and the white oils in so far as the kill of scale insects is concerned, but the white oils, containing oils of a further stage of refinement, can undoubtedly be used with a much greater degree of safety to the tree. The objective aimed at by the manufacturers of these oil sprays is to obtain as high a percentage mortality in the scale insects as is possible without unduly reducing the margin of safety to the tree, and in this respect a reasonable compromise has generally been achieved.

The preparation of an oil spray for application in the orchard commences with the accurate measurement of the oil and water required. The oil is poured into a tin, and twice its volume of water is added, this mixture being forced through a fine nozzle of a bucket pump or poured from one container to another several times until a satisfactory emulsion is obtained. The mixture is then added to the balance of the water which is already in the spray tank. Growers are reminded that the manufacturers' directions should be carefully read before preparing and applying the spray.

Oil sprays should be applied in a well emulsified condition, and the operator should make certain that the spray mixture is kept efficiently agitated while being applied. An accumulation of surplus oil at the base of the tree may cause injury to the lower portion of the trunk and the adjacent portions of the root system, this injury being particularly liable to occur in the case of young trees. It can, however, be obviated by earthing up round the base of the trunk before commencing operations and removing the soil soon after spraying. Trees should not be sprayed with oil when experiencing dry conditions, and in the case of citrus it is not desirable to use oil sprays during the dormant period. Furthermore, the use of these oils during high summer temperatures is attended with danger. Healthy well-watered citrus trees may be sprayed with white oils at a temperature close on 100°F., but, in general, spraying with oils should be confined to cooler weather. It is also well to remember that sickly trees are more liable to spray injury than healthy trees.

Oil and nicotine sulphate may be used as a combination spray, but as stated when discussing arsenate of lead, a mixture of an oil spray and arsenate of lead possesses certain disadvantages and dangers.

For many years lime sulphur and oil were regarded as constituting a dangerous combination, and indeed in the case of many oils this is still so. Certain proprietary oils, however, are now being marketed as safe for mixing with lime sulphur. Such a combination spray is a very useful one but it should be employed with considerable care, and should not be applied while high temperatures are ruling. Experience indicates that the maximum temperature at which this combination spray may be used is in the vicinity of 90°F., but it is better to cease its application before that temperature has been reached.

Oil is now frequently added to Bordeaux mixture when the latter is being used in citrus orchards. The application of Bordeaux mixture for the control of fungous diseases of citrus unfortunately tends to markedly increase scale infestation, and, in order to obviate such an eventuality, 1 per cent. of a good oil spray is frequently added to the mixture. The oil is first well emulsified in double its own volume of water and is then added to and well stirred into the Bordeaux mixture. Care must be taken to ensure that no free oil is present in the spray while is is being applied.

The application of an oil spray may follow the fumigation of citrus trees within a few days and fumigation may follow an oil spray after a similarly brief interval, but it is better to allow at least two weeks to elapse between each treatment. Normally, however, there should be no necessity whatever for the two treatments to be given at such a brief interval as two weeks. An oil spray should not be used immediately after or before the application of a lime sulphur spray or a sulphur dust, and a period of at least one month should elapse between the two treatments.

Should Bordeaux mixture and oil be applied as separate sprays in citrus orchards at least two months must elapse between the application of the Bordeaux mixture and the subsequent use of an oil spray. When the oil spray is applied before the Bordeaux mixture the interval may be somewhat shorter, but it is seldom necessary to apply these two sprays in that order.

Spraying oils are most commonly used for the control of scale insects on citrus, but they are also similarly used on deciduous fruit trees at certain seasons of the year.

KEROSENE EMULSION.

Kerosene emulsion was for many years generally employed for the control of scale insects and aphids, but for such purposes it has now been very largely supplanted by other insecticides. There are, however, still occasions on which growers may desire to use it for it possesses the great merit of being prepared from ingredients obtainable at any country store.

A formula frequently used in its preparation is ½ lb. hard soap, 1 gallon water and 2 gallons kerosene. The soap is added to the water and dissolved therein by boiling. This mixture is then removed some little distance from the fire, and the kerosene is added while the soap solution is still hot. The soap, water, and kerosene are then thoroughly emulsified by churning up for five or ten minutes by means of a small spray pump or syringe. A thorough emulsion must be obtained, otherwise the presence of free oil will cause foliage injury. Although the stock solution prepared in the manner just described may keep for some time, it is generally considered desirable to prepare it as required.

The stock solution has to be diluted prior to use, the proportion of water to be added being determined by the species of plant to be sprayed and the species of pest to be destroyed. Some investigators claim that no greater strength than one part of stock solution to fifteen parts of water should be used, while others consider a one to ten strength reasonably safe.

When discussing oil sprays a suggestion was made as to how an accumulation of potentially injurious spray at the base of a tree can be dealt with. The precaution then mentioned should also be adopted in the case of trees sprayed with kerosene emulsion.

CRUDE OIL EMULSION.

A crude oil emulsion may be prepared in exactly the same manner as kerosene emulsion except that crude oil is substituted for the kerosene. The stock solution in this case is diluted by the addition of one part of the stock solution to seven parts of water. This spray has been used against caterpillars in army-worm outbreaks, and for such a purpose it is of value on dairy farms or other grazing holdings on which the owner desires to use a non-arsenical insecticide. The above ground portions of plants with which this spray makes contact are killed together with the insects.

TAR DISTILLATE WASHES.

Proprietary tar distillate washes are now employed for the control of a number of pests, and for certain purposes they are quite effective. Their use, however, has to be confined to seasons of the year when the treated trees are completely dormant, and they are employed only in deciduous fruit orchards. They should be applied before the buds begin to swell, otherwise severe injury may be inflicted.

Tar distillate washes can be profitably employed to kill the over-wintering eggs of the green peach aphis. They are also used against San José scale and they can be of assistance in black peach aphis control.

SOAP AND WASHING SODA MIXTURE.

A soap and washing soda spray has been found very effective for the control of the pink wax scale, for which purpose it has largely displaced the old washing soda wash. The latter spray was sometimes slightly drastic in its effect on treated trees, hence its waning popularity.

The spray is prepared by dissolving twenty-four cakes of Sunlight soap, or an equivalent quantity of similar soap, and 12-14 lb. of clean, fresh washing soda in 75 gallons of water. The washing soda is dissolved in a small quantity of the water which is brought to the boil and the soap, which should be shredded, is then added. The mixture is further heated until the soap has dissolved and is added to the balance of the 75 gallons of water, the spray being agitated during application.

WASHING SODA WASH.

Washing soda wash is prepared by dissolving 1½ lb. of clean fresh washing soda in 4 gallons of water. This spray may be used for the control of white wax on citrus against which the soap and washing soda mixture is not so effective. As already indicated, however, the effect of the washing soda wash on the treated trees may be rather severe.

DERRIS AND CUBE.

Insecticides prepared from certain species of Malayan plants belonging to the genus Derris have recently come into favour. These plants are well known as a source of fish poison both in Malaya and in the South Seas, and it has now been demonstrated that several active principles, including rotenone, which are present in derris, are highly toxic to some species of insects. The derris insecticides act both as contact sprays or dusts and as stomach poisons, and they possess the great merit of being safe for application to edible portions of plants due for harvesting at an early date. Insecticides of this type have given good results against the common cabbage caterpillar, the onion thrips, and various species of aphids.

Cubé is the name applied to a group of South American fish poison plants which have also been found to contain these active principles. They are now a source of insecticides similar to those obtained from the genus Derris.

The derris and cubé insecticides are generally marketed as proprietary lines and the firms selling the various brands usually supply full details as to the strength of application.

PYRETHRUM.

Pyrethrum powder, derived mainly from the flower heads of species of Chrysanthemum was formerly used for the control of insects such as the banana rust thrips. Deterioration on exposure and variability in results led to loss of popularity, some measure of which, however, has been restored by its demonstrated value against the red-shouldered leaf beetle.

Recently, standardised extracts have been manufactured, thus eliminating the objectionable feature just mentioned, and extracts of pyrethrum are now used very extensively in the manufacture of fly sprays.

A home-made pyrethrum spray may be prepared by mixing ½ lb. of pyrethrum in 1 gallon of kerosene, the mixture being agitated every now and again during a period of two hours. It is then allowed to settle and the clear liquid is drawn off and used as a fly spray. If water-white kerosene is employed in its preparation this spray can be used in furnished rooms. Stocks of this insecticide should be stored in tightly closed containers.

LIME SULPHUR.

Lime sulphur is an excellent dual purpose spray, being a valuable insecticide and an efficient fungicide. It was formerly prepared on the orchard by boiling a mixture of sulphur, lime, and water, but the home-made preparation has largely been displaced by the commercial product which is obtained in concentrated form ready for dilution.

The insecticidal value of lime sulphur is largely dependent on the polysulphide content, a factor capable of determination only by analysis. The old method of discussing the strength of the solution and the effectiveness of lime sulphur in terms of the Baumé hydrometer reading is now generally regarded as unreliable.

Although lime sulphur is a useful insecticide against certain insects, it is more important as a fungicide. For this reason a much fuller account of the method of preparation and dilution of this material is given in the chapter dealing with fungicides, in Part II. of this volume, to which the reader is referred.

Lime sulphur may be used on citrus at strengths varying between 1 in 10 (2·12 polysulphide) and 1 in 35 (0·61 polysulphide), the stronger sprays being used in the colder months. Lime sulphur is effective against Maori mite and white louse, both important pests of citrus, and it is also used for the control of San José scale on deciduous fruits in the Stanthorpe district, being there applied at a strength of 1 in 10 (2·12 polysulphide) during the winter months when the trees are dormant.

A combination spray of lime sulphur and arsenate of lead and a combination of lime sulphur and oil have been discussed in earlier paragraphs, and the precautions necessary in preparing and applying such combinations have been adequately indicated. Lime sulphur is also sometimes combined with nicotine sulphate to control certain fungous diseases and soft bodied insects by a single treatment. When such a combination is employed the soap, which is included in the ordinary nicotine sulphate spray, should be omitted because it reacts with lime sulphur. No activator, however, requires to be substituted for the soap because the lime sulphur itself performs that function.

The discussion on oil sprays includes a reference to the period that should elapse between the application of a lime sulphur spray and an oil spray. Lime sulphur following Bordeaux mixture at a brief interval may produce a dark stain on the sprayed surfaces.

SULPHUR.

Sulphur is used to control certain pests and diseases, the pests against which it is generally employed being red spiders and other mites.

This insecticide may be obtained in the form of flowers of sulphur or sublimed sulphur, which is produced by the condensation of sulphur vapour. It is also procurable in the form of ground sulphur, which is now available in the degree of fineness essential for application as an insecticidal dust. All ground sulphurs, however, do not necessarily possess the requisite degree of fineness, and this essential should always be specified when ordering this or any other type of sulphur for dusting purposes. Ground sulphur is prepared by grinding lump sulphur, and it should be noted that the grinding imparts a lighter yellow colour than is present in flowers of sulphur. The ground sulphur sometimes tends to become lumpy, while small but injurious quantities of free sulphuric acid may be present in flowers of sulphur.

Hydrated lime may be added to sulphur to the extent of one-third of the sulphur, thereby promoting adherence to the treated foliage, and ease of application while at the same time counteracting the possible presence of injurious quantities of free sulphuric acid.

The attention of the reader is directed to a reference in the discussion on oil sprays to the period that should be allowed to elapse between the application of a sulphur dust and an oil spray.

Sulphur dusting is usually carried out early in the morning when the dew is still present on the foliage, and should not be undertaken on windy days. Sulphur dust is also applied in citrus orchards in the early evening, after sundown, when the dew is falling.

Sulphur may be used as a fumigant for stored products, the sulphur on being burned, combining with the oxygen of the air to form sulphur dioxide. Sulphur may thus be employed for the control of cheese mites.

Colloidal sulphur is another form of this valuable insecticide which has recently come into prominence. The particles in this case are extremely small and the colloidal sulphur mixes readily with water.

NICOTINE SULPHATE AND NICOTINE.

Nicotine sulphate has long enjoyed popularity as an effective spray for soft-bodied insects such as aphids and thrips. It acts as a fumigant, and is one of the safest sprays to apply in so far as its effects on the sprayed plants are concerned. Nicotine is liberated relatively slowly from nicotine sulphate under normal conditions, hence in preparing a nicotine sulphate spray it is usual to add a substance as an activator which will release the essential toxic principle in the spray—namely, the nicotine. For this purpose soap is usually incorporated in a nicotine sulphate spray, a standard formula being nicotine sulphate (40 per cent.) ½ pint, soap 2lb. and water 50 gallons.

Three combination sprays in which nicotine sulphate is combined with arsenate of lead, an oil spray, and lime sulphur, respectively, have already been discussed in earlier paragraphs. Nicotine sulphate may also be combined with Bordeaux mixture in cases where the grower desires to control certain fungous diseases and soft-bodied insects by one and the same spray application. Nicotine sulphate requires no activator in this combination, the Bordeaux mixture supplying all that is required in that respect.

Nicotine sulphate dusts are now largely employed instead of the spray, the nicotine sulphate being mixed with a fine powder which acts as a carrier and also usually functions as an activator to liberate the toxic nicotine from the nicotine sulphate. A good nicotine sulphate dust should be free from lumps, and when discharged from a duster the resultant cloud should float lightly in the air.

A more recent tendency has been to employ nicotine instead of nicotine sulphate in preparing these dusts, a material advantage being that a much more rapid volatilisation is obtained with the nicotine than is the case with nicotine sulphate dusts.

Nicotine and nicotine sulphate dusts deteriorate if exposed, and should accordingly be carefully stored in air-tight containers. Furthermore, it is desirable to purchase only sufficient dust to comfortably do the immediate work, thus leaving little or no surplus to deteriorate in storage.

The sprays are very useful against woolly apple aphis, and the dusts are the most satisfactory insecticide yet evolved for the control of banana rust thrips.

HOME-MADE TOBACCO EXTRACTS.

Home-made tobacco extracts have long been out of favour as sources of nicotine sprays, preference now being given to nicotine sulphate sprays and nicotine sulphate or nicotine dusts prepared under carefully controlled conditions permitting standardisation at known strengths. The revival of tobacco growing, however, has created a considerable source of waste tobacco, and frequent inquiries are now received regarding the preparation of extracts from such waste material.

The tobacco plant varies considerably in its nicotine content, and the strength of a home-made extract must of necessity be subject to considerable variation. Some formulæ range from 1 lb. of waste tobacco to 1 gallon of water to 1 lb. of waste tobacco to 2½ gallons of water. It has been suggested that 1 oz. of washing soda be added to each 6 gallons of water.

In preparing the extract by cold soaking, the mixture is left standing for a period of 24 to 48 hours with occasional stirring; the fluid is then drained from the tobacco, and after straining is ready for application as a spray.

The extract may alternatively be prepared by heating the ingredients in a covered container over a fire. Heating continues until the mixture is on the point of boiling, when it is removed from the fire. After cooling the fluid is drained off, strained, and is then ready for use.

These tobacco extracts should be used straight away as they deteriorate on storing. Soap may be added as in the case of proprietary nicotine sulphate sprays.

WETTING, SPREADING, AND STICKING PROPERTIES OF SPRAY FLUIDS.

As mentioned in an earlier paragraph, the successful application of insecticides depends on their ability to destroy the insect with safety to the treated plant at a cost that can be borne by the product to be marketed.

Success in spraying is, therefore, in large measure dependent on the ability of the operator to obtain a maximum degree of efficiency with a minimum expenditure of spray fluid. This desirable objective will be achieved only when the sprayed surface of the plant or insect is thoroughly, intimately, and evenly covered with a thin film of the spray fluid. In addition, the toxic element of the spray should remain on the sprayed surface for a sufficient period of time to achieve the objective for which it was applied.

Some spray fluids do not in themselves possess satisfactory wetting and spreading properties no matter what plant they are applied to, while such plants as the cabbage and certain insects—*e.g.*, mealy bugs—present decided difficulties in spray application. Nicotine sulphate with soap as an activator and oil sprays require no spreader, but the addition of such a supplementary substance is necessary in the case of arsenate of lead. A lime sulphur spray is also much improved by the addition of a spreader.

Where it has been found impracticable to obtain the desired degree of efficiency in the application of the spray fluid, it has become the practice to add supplementary substances variously known as wetters or spreaders and stickers.

The power of a supplementary substance to wet a surface may depend on its ability to produce chemical changes thereon—*e.g.*, a solvent effect may be produced on the waxy coating of the cabbage leaf or mealy bug. In addition, the wetting power is largely dependent on the physical interactions between the spray fluid and the sprayed surface. From a practical point of view the objective, however, of the supplementary substance is to ensure thorough wetting—*i.e.*, intimate contact between the spray fluid and the sprayed surface.

A further essential in the supplementary substance is its ability to ensure that the sprayed surface is completely covered with a film of spray fluid. The achievement of such an objective means that the spray fluid will not become aggregated in droplets, a development which would leave much of the surface unprotected or many of the insects untreated.

Wetting and spreading are not just one and the same thing, but any one of the commonly used supplementary substances will produce both effects in a spray fluid that is deficient in wetting and spreading properties, and it is generally referred to as a spreader. Soap, saponin, gelatine, and calcium caseinate have been used as spreaders, but before adding a spreader to a spray fluid the operator should satisfy himself

that the addition can be made without reducing the toxicity of the spray or rendering the spray fluid more liable to injure the sprayed plants—*e.g.*, soap should not be used as a spreader for arsenate of lead.

Stickers, as their name suggests, are supplementary substances, the addition of which to the spray fluid increases the ability of the toxic substance to adhere to the sprayed surface. Actually the spreader added to a spray fluid functions also as a sticker. While the threefold purpose of a supplementary substance has been outlined so that the reader may appreciate the purpose of the addition, he need concern himself only with the use of one satisfactory agent of this type.

Recently a number of proprietary spreaders have been placed on the market by reputable firms backed in one instance by the claim that the material is "compatible with practically every spraying fluid."

PARADICHLOROBENZENE.

The white crystalline substance known as paradichlorobenzene is now extensively used in Queensland, being employed mainly as a soil fumigant for the control of white grubs in sugar-cane plantations. It can also be used in the control of white ants attacking the roots of trees, and it fills a useful minor role in bookcases for the protection of the books from the ubiquitous cockroaches. It evaporates, rather after the manner of flake naphthalene, to a fumigant gas with a characteristic somewhat sweetish odour. When employed as a soil fumigant paradichlorobenzene should be applied when the soil is in a friable moderately moist condition and not when it is either excessively wet or dry.

CARBON BISULPHIDE.

Carbon bisulphide is extensively used for the fumigation of insect-infested seeds, cereals, and potatoes, and is also employed for the destruction of ants' nests, being a very satisfactory insecticide for both purposes.

This chemical rapidly evaporates on exposure to the air and forms a highly explosive and inflammable gas. Farmers using it should accordingly make certain that it does not come into contact with a flame or highly-heated pipes. Furthermore, it is essential to refrain from smoking when using carbon bisulphide, and the containers in which it is supplied should not be exposed to strong sunlight. The operator should also make every effort to avoid inhaling quantities of the gas, for serious consequences will ensue if this precaution is not observed.

Satisfactory results with carbon bisulphide fumigation are obtainable only when certain temperatures prevail, and it is generally considered that a temperature of at least 70°F. is desirable. It has been demonstrated that fumigation at less than 60°F. has been productive of disappointing results. For this reason fumigation should not be undertaken in cold weather, and it should start in the morning, so as to obtain the benefit of the higher day temperatures.

The seed to be treated for insect infestation is placed in a suitable container, which should be as air-tight as possible. The carbon bisulphide is then poured into saucers or other suitable dishes placed on top of the seed so that the gas, which is heavier than air, will diffuse throughout the container, which should be immediately tightly closed.

The general practice is to allow 4 or 5 lb. of the carbon bisulphide to each 1,000 cubic feet of the container, and to leave the seed exposed to the gas for thirty-six hours. Cowpea and allied seed, however, should be fumigated for twenty-four hours only. The fumigated seed should

then be aired to remove the gas. The germination of mature seed is not affected if dry when treated and if the precaution of airing the seed after treatment is observed.

Reinfestation of fumigated seed will take place if steps are not taken to prevent it, hence the usual procedure is to store the treated seed in tightly closed containers giving little chance of reinfestation.

Cereals and potatoes are fumigated in a rather similar manner except that, in the case of the latter, the weaker dosage of carbon bisulphide is used.

HYDROCYANIC ACID GAS.

Another extremely useful fumigant is hydrocyanic acid gas, which is extensively employed for the fumigation of ships, buildings, imported raw materials, dormant nursery stock, and citrus orchards.

This colourless gas is lighter than air and diffuses rapidly, a smell of bitter almonds being the only means whereby its presence can be readily detected. It is extremely poisonous to insects, animals, and man, and must therefore be handled with great care. It is a highly-efficient insecticide for the fumigation of scale-infested citrus trees, and produces no appreciable injury in such trees if the requisite precautions are observed in its application.

The discussion of hydrocyanic acid gas fumigation in this chapter will be confined to its application to insect-infested citrus orchards, and the first point to note in connection therewith is the fact that the gas may be effectively generated in any one of several ways.

The method originally employed is still frequently used in Queensland, and is known as the pot system, in which the gas is generated under a sheet by the interaction of potassium cyanide, sulphuric acid, and water. The tree to be fumigated is completely enclosed by pulling a sheet over it by means of poles not less than 18 feet in length for average size trees. The poles should, in general, be about 2 feet longer than the height of the trees to be fumigated. The height and diameter of the enclosed space are then obtained by comparison with a pole plainly marked in feet, and by reference to Table I. the operator ascertains the quantity of materials required for the fumigation of the tree he has just covered and measured. The requisite quantities of these materials are accurately weighed or measured, and the water is poured into an earthenware jar. The sulphuric acid is then carefully and slowly added to the water, and the jar is placed under the fumigating sheet covering the tree. The potassium cyanide is immediately dropped into the mixture of water and sulphuric acid, and the portion of the sheet that has been raised to permit the charging of the pot is promptly closed. A word of warning must be issued with respect to the addition of the sulphuric acid to the water, because if care is not exercised in doing so some of the acid may splash on to the operator and inflict very severe burns.

The proportion of water, sulphuric acid, and potassium cyanide is 3:1:1, the amount of water and sulphuric acid being expressed in fluid ounces and the potassium cyanide in ounces avoirdupois. It is desirable at this stage to mention the fact that the so-called potassium cyanide is generally a mixture of potassium cyanide, sodium cyanide, and a little inert matter. However, its equivalent value in pure potassium cyanide has to be declared on the labels. The requisite amounts of potassium cyanide necessary for the fumigation of various sizes of citrus trees

TABLE I.
POTASSIUM CYANIDE.
45 Minutes Exposure.
Diameter of Tree (feet).

Height of Tree (feet).

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
4	1	1	1	1																4
5	1	1	1	1½	2															5
6		1½	1½	2	2	2½	3	4	4											6
7		1½	1½	2	2½	3	4	4	4	5										7
8				2½	3	3	4	4	5	6	6	6	7							8
9				2½	3	3	4	4	5	5	6	6	7	7						9
10				3	3	4	4	4	5	5	6	6	7	8	9					10
11					4	5	5	5	6	6	7	7	8	9	10					11
12						5	5	6	6	6	7	8	8	10	11	12	13	15	17	12
13						6	6	7	7	7	8	9	9	12	13	14	15	16	18	13
14							6	7	7	8	9	10	11	13	14	15	17	18	18	14
15								7	8	8	10	11	12	14	14	16	18	20	20	15
16									9	10	12	12	13	14	15	17	18	20	21	16
17										12	13	13	14	15	16	18	20	22	22	17
18											13	13	15	16	18	20	22	23	24	18
19												15	16	18	19	21	23	25	25	19
20													17	19	21	23	24	25	26	20
21													19	19	21	23	25	26	27	21
22														21	22	24	25	26	27	22
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	

Doses in Ounces.

Proportion: Water, 3; Sulphuric Acid, 1; Potassium Cyanide, 1.

are shown in Table I. Once the requisite quantity of potassium cyanide is known for any particular tree, the quantities of sulphuric acid and water required in the fumigation of that tree are readily ascertainable according to the proportion mentioned earlier in this paragraph.

The duration of the fumigation is generally forty-five minutes, at the end of which period the sheet or tent is transferred to the next tree. The materials used for tents and their handling and measurement are discussed at the end of these notes on hydrocyanic acid gas.

TABLE II.

CYANOGAS DUST.

45 Minutes Exposure.

Diameter of Tree (feet).

Height of Tree (feet).	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
4	1	1	1	1½																4
5	1	1	1½	1½																5
6	1	1½	1½	1½	2	2½	3	4	4											6
7	1	1½	1½	2	2½	2½	3½	4	5	5½										7
8		1½	1½	2	2½	3	4	4½	5½	6½	7½	8½	10							8
9			2	2½	2½	4	4½	5	6	7	8½	9½	11	12½						9
10				2½	3	4	4½	6	7	8	9½	10½	12	14	15½					10
11					3½	4½	5	6½	7½	9	10	12	13½	15	17	19				11
12					3½	4½	6	7	8	10	11	13	14½	16½	18½	20½	23	25	27½	12
13							6	7½	9	10½	12	14	16	18	20	22	24½	27	30	13
14							7	8	9½	11	13	15	17	19	21½	24	26½	29	32	14
15								8½	10	12	14	16	18	20½	23	25½	28½	31	34	15
16								9	11	13	15	17	19½	22	24½	27½	30½	33½	36½	16
17									11½	13½	16	18	20½	23	26	29	32	35½	39	17
18									12½	14½	17	19	22	24½	27½	31	34	37½	41	18
19									13	15½	18	20½	23	25	29	32½	36	39½	43½	19
20									13½	16	18½	21½	24½	27½	30½	34	38	42	46	20
21												22½	25½	29	32½	36	39½	44	48	21
22												23½	26½	30	34	37½	41½	46	50½	22
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	

Doses in Ounces.

Table recommended by manufacturer. Modifications may be made in this table by the manufacturer, and citrus growers should accordingly obtain the latest table when purchasing their supplies of this fumigant.

Fumigation by the pot method, which can be carried out only during the night, necessitates the handling of a very corrosive acid and a highly poisonous chemical. Hence the pot system is by no means an ideal one, and it has recently been largely displaced by other methods of generating the gas.

TABLE III.

CALCID BRIQUETTES.

40 Minutes Exposure.

Diameter of Tree (feet).

Height of Tree (feet).

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
4	1	1	1½	1½																4
5	1	1	1½	2																5
6	1	1½	1½	2	2½	2½	3	3½	4											6
7	1	1½	2	2	2½	3	3½	4	4½	5										7
8		1½	2	2½	2½	3	3½	4½	5	5½	5½	6	7							8
9			2	2½	3	3½	4	5	5½	5½	6	7	8	9						9
10				2½	3	3½	4½	5	5	6	7	8	9	10	11					10
11					3½	4	4½	5	6	7	8	9	10	11	12	13				11
12					3½	4	5	5	6	7	8	10	11	12	13	14	16	17	19	12
13							6	6	6	7	9	10	11	13	14	16	18	20	22	13
14							6	6	7	8	9	11	12	14	16	17	19	21	23	14
15								6	7	8	10	11	13	15	17	19	21	23	25	15
16								7	8	9	11	12	14	16	18	20	22	24	27	16
17									8	10	11	13	15	17	19	21	24	26	29	17
18									9	10	12	14	16	18	20	22	25	28	30	18
19									10	11	13	15	17	19	21	24	26	29	32	19
20									10	11	13	15	18	20	22	25	28	31	34	20
21												16	19	21	24	26	29	32	35	21
22												17	19	22	25	28	31	34	37	22
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	

Doses in Number of Briquettes.

Table recommended by manufacturer. Modifications may be made in this table by the manufacturer, and citrus growers should accordingly obtain the latest table when purchasing their supplies of this fumigant.

The most generally used alternative to the pot system is the generation of the gas by the use of calcium cyanide, which is obtainable in Queensland in the form of Cyanogas and Calcid Briquettes. The calcium cyanide in a finely divided condition interacts with the water

vapour in the atmosphere, and hydrocyanic acid gas is evolved. In practice, the Cyanogas "A" dust, which is the form of Cyanogas generally employed in this State, is blown under the sheet by means of a forge type blower, although some growers, in order to obviate the cost of the blower, place the necessary amount of dust in a saucer and throw it under the sheet, using a sweeping motion in order to obtain a good distribution of the dust. Application by the special blower is to be preferred to the use of the saucer. A special machine grinds the Calcid Briquettes and blows the resultant powder under the sheet.

The number of ounces of Cyanogas dust and the number of Calcid Briquettes required for the fumigation of various sizes of citrus trees will be found in Tables II. and III., respectively.

Fumigation by means of calcium cyanide possesses many advantages over the old pot system, the principal of which are the simplicity of the operation, the elimination of the highly-corrosive sulphuric acid, the fact that calcium cyanide, although itself a very strong poison, is safer to handle than potassium cyanide, the fact that the fumigation can be done in the day time under widely varying climatic conditions, and the further fact that calcium cyanide is more effective for most purposes on a citrus orchard.

Liquid hydrocyanic acid gas has also been employed elsewhere as a substitute for the pot system, but it has not been used in Queensland.

Fumigation can be effectively carried out without any appreciable undesirable consequences to the fumigated trees, but to ensure safe and successful treatment certain precautions must be observed.

The dimensions of the tree must be correctly ascertained, the appropriate quantity of chemical or chemicals and water definitely determined, and then accurately measured out. Trees should not be fumigated when wet, and if the work is being carried out at night the incidence of a heavy dew renders the continuance of fumigation undesirable. Furthermore, wet sheets should not be used in fumigation.

Fumigation by the pot system is inadvisable when the temperature exceeds 75° F. on the coast or 80° F. in inland citrus areas. With calcium cyanide, however, the safe temperatures are generally 10°F. to 15°F. higher when normally healthy trees are being fumigated under average good conditions. However, special care should be exercised when fumigating near the temperature limit of safety, and on hot summer days operations should cease between 12.30 p.m. and 3 p.m.

Trees on soil that is very wet, either as a result of rain or irrigation, should not be fumigated, but, on the other hand, drought-stricken trees are more susceptible to injury than those enjoying normal moisture conditions. Fumigation may cause excessive injury to trees carrying a large amount of tender young growth, and in such cases treatment should be delayed as long as is practicable. Young fruit is also susceptible to injury, and trees bearing fruit of a smaller diameter than three-quarters of an inch should not be fumigated. Finally, growers should remember that trees with a Bordeaux mixture residue may be very seriously injured by fumigation. Hence a tree that has been sprayed with Bordeaux mixture should not be fumigated until at least six months have elapsed, and, indeed, nine or twelve months is a safer interval. Reference has been made in an earlier paragraph to the interval that should elapse between fumigation and the application of an oil spray, and the reader's attention is directed thereto.

Before leaving the subject of fumigation, some mention must be made of the tent equipment required for the purpose. The tents or sheets are usually made of duck or drill, and must be sufficiently closely-woven to prevent the rapid escape of the gas and to stand the rough usage to which they will be subjected without being unduly heavy. It is generally considered that 8-oz. army duck is better than drill and is the best material than can be employed. Recent departmental experiments, however, have shown that a medium-weight, closely-woven calico gives satisfactory results. It is considerably cheaper than duck, but its life would not be so long. The sheets are usually eight-sided, and their diameter varies from 30 to as much as 80 feet, depending on the size of the trees to be covered. A well-shaped tree 12 feet in height can usually be covered by a 36-foot sheet.

Chapter II.—FRUIT PESTS.

Among the insect pests dealt with in this chapter are Queensland fruit fly, codling moth, San José scale, woolly apple aphis, grape phylloxera, grape vine leaf blister mite, black peach aphis, green peach aphis, and red mite, all mainly or exclusively pests of deciduous fruits. The citrus pests discussed herein are bronze orange bug, larger horned citrus bug, black passion bug, red scale, circular black scale, mussel scale, pink wax scale, white louse, Maori mite, fruit fly, fruit sucking moths, citrus root bark channeller, citrus leaf-eating weevil, and citrus branch borers. The banana pests dealt with are banana weevil borer, banana rust thrips, banana silvering thrips, fruit-spotting bugs, banana fruit-eating caterpillar, and fruit fly. Readers will also find fig beetle, fig leafhopper, pineapple mealy bug, pineapple white grub, strawberry and pineapple thrips, and yellow peach moth discussed in appropriate detail.

QUEENSLAND FRUIT FLY.*

The maggots of this notorious insect feed voraciously in the fruit of many trees and other plants, deciduous fruits being particularly susceptible to attack. Citrus, papaw, and mango may also suffer severely, but, fortunately, the banana is very rarely attacked, and then only in the case of over-mature bunches, which should be cut solely for home or local consumption. The maggots tunnel throughout the fruit (Plate 2; fig. 1), destroying much tissue in their progress and setting up decomposition, the combined effect being to render the fruit unfit for marketing.

Life History and Habits.

The creamy-coloured slightly-curved eggs (Plate 1; fig. 1) of the Queensland fruit fly are laid in batches of as many as six or seven in the tissue of the selected fruit just underneath the puncture made in the skin thereof by the female fly. The eggs hatch in two or three days in midsummer, and the creamy-white legless tapering maggot (Plate 1; fig. 2) feeds throughout the tissue of the fruit. The full size of one-third of an inch in length is attained in a week in the warmer weather, and the maggot then leaves the fruit and pupates in the soil just below the surface. The pupa is formed within a hard-shelled reddish-brown pupal case (Plate 1; fig. 3), and in this non-feeding stage the maggot's tissues undergo a complete reorganisation, resulting in the production of the prettily marked reddish-brown fly (Plate 1; fig. 4) at the end of about one week in midsummer. The life cycle may thus be completed in little more than a fortnight in summer, but in the colder months all the life cycle stages are of much longer duration.

Control.

Successful control of this pest necessitates strict attention to orchard hygiene, and all waste and fly-infested fruit should accordingly be promptly gathered up and adequately disposed of. If fallen infested fruit is allowed to lie on the ground the fruit fly maggots contained therein will leave the fruit on becoming full grown, and will pupate in the soil to produce a fresh brood of flies. When the infested fruit has been gathered up it may be disposed of by burying, boiling, burning,

* *Chætodacus tryoni* Froggatt.

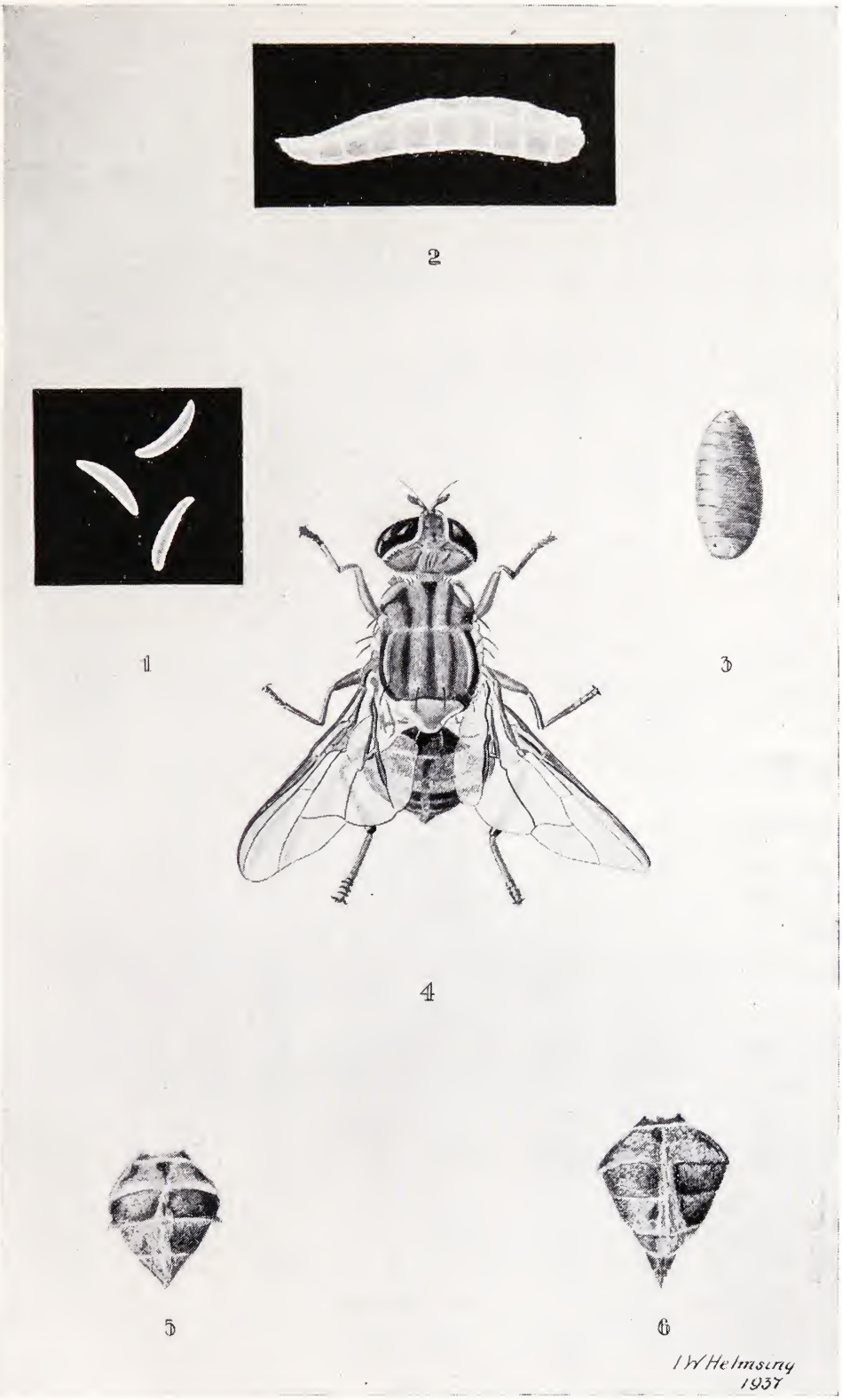

Plate 1.

QUEENSLAND FRUIT FLY.

Fig. 1.—Eggs × 10.
Fig. 2.—Maggot × 4.
Fig. 3.—Pupal case × 4.
Fig. 4.—Adult × 7.
Fig. 5.—Male abdomen × 7.
Fig. 6.—Female abdomen × 7.

Face page 20.

or immersing in water. If the fruit is buried, care should be taken to ensure that it has a soil covering of at least 18 inches, for if only a light covering is given the flies will succeed in completing their development and will emerge from the soil. None of these methods of disposal are ideal, and hence it has been decided that, at least in so far as the Stanthorpe district is concerned, the pit method of disposal is more satisfactory. The pit should be 6 feet by 5 feet, with a depth of 20 feet, and a suitable fly-proof cover should be provided. The waste and infested fruit is tipped into the pit. Pits of somewhat smaller dimensions are employed in the citrus districts, and boiling is also a common method of disposing of fly-infested citrus.

Luring has been demonstrated to be a successful control measure in the deciduous fruit orchards, and a departmental lure much used therein has the following formula:—synthetic vanilla essence $\frac{1}{8}$ fluid ounce (a teaspoonful), household ammonia $\frac{1}{2}$ fluid ounce (a tablespoonful), and water 26 fluid ounces (a wine bottle full). About 6 fluid ounces of this lure is sufficient for the baiting of one trap. The lure is placed in glass fly traps, which are obtainable at reasonable prices, and these are hung in suitable trees. Large leafy trees in a sheltered position should be selected, and the traps placed in the shadiest portions thereof, being suspended by tie wire. Many growers in the Stanthorpe district place the traps so that each hangs just above a few leaves which will act as a landing platform for the flies. Some growers, however, prefer to use a small landing board with the fly trap, the whole being suspended by tie wire. If a landing board is used the fly trap should have short glass legs or should rest on thin pieces of pine attached to the board so as to permit the flies obtaining easy ingress to the trap from the landing board. It may at first be desirable to move the traps from one set of trees to another in order to ascertain which trees in an orchard are likely to yield the best catch of flies. The traps should receive regular attention, the lure being renewed at least twice weekly; more frequent recharging may be necessary in very hot weather when evaporation takes place rapidly. The captured flies and other insects, which may be present in considerable numbers, should be removed from the traps when the lure is being renewed, and every endeavour should be made to keep the traps as clean and bright as practicable. At least ten traps per acre are required to ensure protection of maturing fruit in the Stanthorpe district, and the dates on which these must be placed and maintained in the orchards in that district are specified by regulation. In deciduous fruit districts, where no such regulation is in force, it is suggested that fruit fly traps be placed in position at least six weeks before the fruit to be protected normally matures and that the traps be kept regularly charged until the fruit has been harvested.

This lure was evolved for use in deciduous fruit orchards, and its application in citrus and other orchards may not always be attended with the same degree of success as has been experienced at Stanthorpe. Furthermore, in citrus orchards the best trees for luring may be those in the most exposed position, whereas, as already indicated, sheltered trees are the most suitable in the deciduous fruit orchards. The suitability of particular citrus trees for luring purposes may be determined by observing the amount of fallen fly-infested fruit under the trees. The landing board is much more commonly used in citrus orchards than in the Stanthorpe district, and with the conditions prevailing in the former the changing of the lure, which of course is

used in citrus in the cooler autumn and spring months, is generally regarded as being necessary only about once a week. The duration of luring in citrus orchards is rather different from that considered necessary in the case of deciduous fruits. Susceptibility to fruit fly injury does not occur in the former until the fruit is almost mature. Hence, luring in citrus orchards need not begin until about three weeks before the commencement of harvesting. Fruit fly, however, is generally of no consequence during May, June, and July, and there is accordingly no necessity to protect citrus maturing during that period. Luring may thus be desirable in the case of grape fruit, navels, Emperor mandarin, and other early varieties during the period extending from late in March to the end of April. Valencias and other late harvested fruit require protection by luring from late July onwards. The dates mentioned are more particularly applicable to the main commercial fruitgrowing districts south of Rockhampton. Elsewhere appropriate adjustments of dates will be necessary, and in most cases the seasons during which protection by luring is desirable will be earlier.

Repellant sprays have recently been the subject of departmental experiments at Stanthorpe, and in connection therewith, it is interesting to note that half a pint of nicotine sulphate and half a gallon of white spraying oil to 40 gallons of water gave very promising results as a fruit fly repellent in several apple orchards. A point about which there is still some doubt is whether or no any cumulative ill effect is produced by the oil in the repeated applications necessary at intervals of one week during the course of a fruit fly invasion. Because of the possibility of such an adverse effect experiments are being conducted with other repellent sprays. The effect of the nicotine sulphate and white oil spray on fruit other than apples will also have to be determined. This spray has also given promising results in the control of codling moth.

A poisoned and sweetened mixture is sometimes sprayed on the foliage at weekly intervals during the period of susceptibility to attack, the spray being applied so that it settles as drops, on which the flies may readily feed with fatal results. It is applied at the rate of 6 fluid ounces per tree to a few shaded patches of foliage, care being taken to avoid coating the fruit with the spray. Arsenate of lead is a poison commonly employed in the preparation of such sprays. A simple formula is arsenate of lead 2½ oz., sugar or molasses 2 lb., and water 4 gallons. One gallon of the water in this formula may be replaced by an equivalent quantity of fruit syrup prepared by boiling 5 lb. of waste or inferior fruit in sufficient water to finally yield the required quantity of syrup. Unfortunately, it is very difficult to assess the value of such a spray in a fruit fly control programme and its possible effect on the bee population cannot be completely ignored, for the honey bee is invaluable to the orchardist in ensuring adequate pollination in the orchard. Such a spray, however, would not be used when the orchards were full of bees at the blossoming period, but would normally be used considerably later.

Where practicable all useless non-commercial fruit trees known to breed fruit flies should be eliminated, as they merely act as an additional source of infestation for the commercial trees.

Covering the trees with such material as old mosquito netting will prevent the flies gaining access to the fruit for egg-laying purposes. Such a control measure, of course, can be adopted only in cases where a few small garden trees require protection.

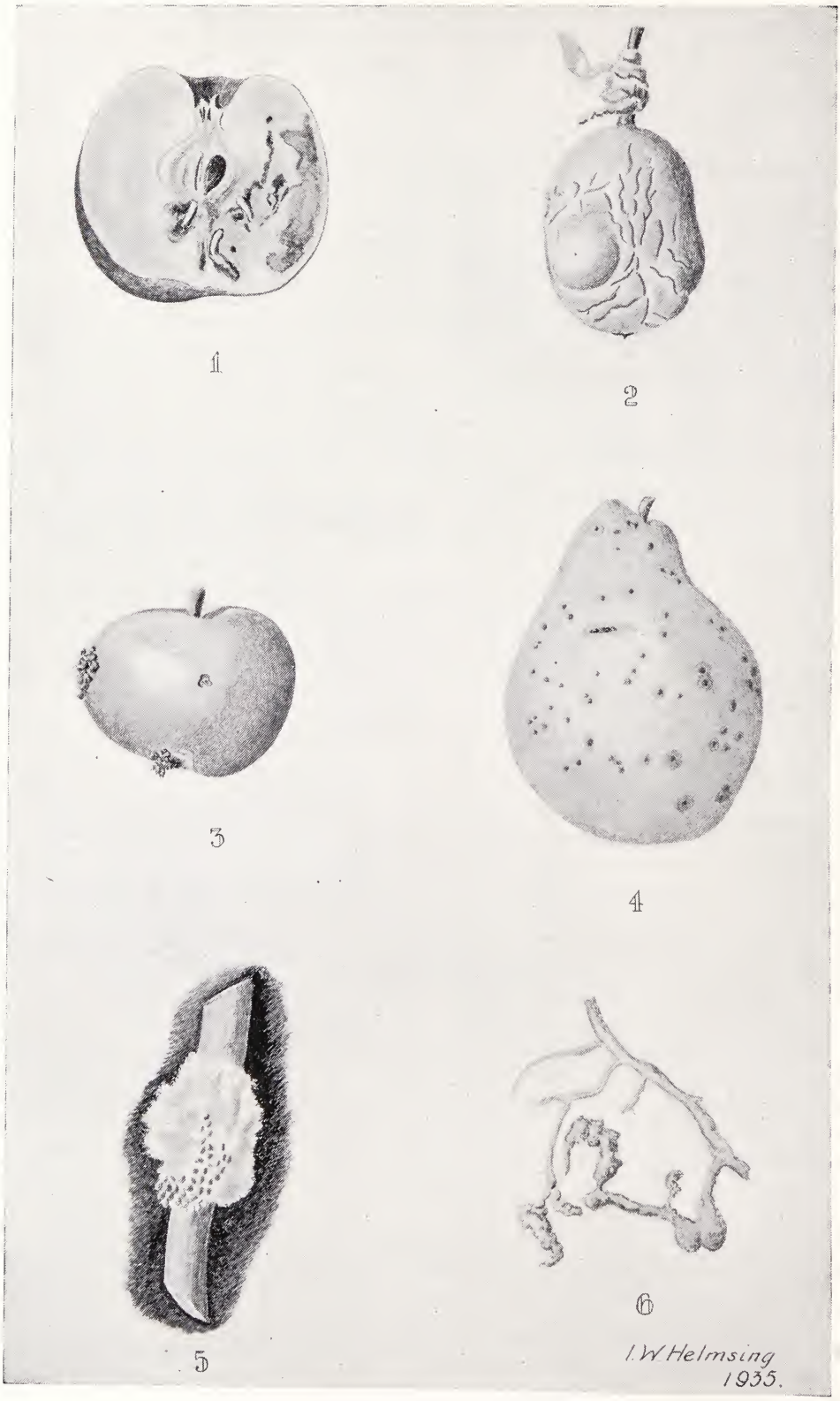

Plate 2.

INSECT ATTACK ON FRUIT TREES AND VINES.

Face page 23.

CODLING MOTH.*

The apple is the fruit most commonly attacked (Plate 2; fig. 3) by the larvæ of the codling moth, but infestation of pears, quinces, and walnuts may be quite appreciable. A few other deciduous fruits have been attacked occasionally, but the insect is pre-eminently a pest of apples.

Life History and Habits.

The pearly-white, semi-transparent egg (Plate 3; fig. 1) of the codling moth is oval-shaped, and is about the size of a small pinhead, and has been rather appropriately described as resembling a fish scale. Egg-laying commences shortly after the petals have fallen from the apple blossoms, and the eggs laid by the spring brood of moths will be found mainly on the leaves. The larvæ hatch from these eggs in about ten days, and usually enter the fruit at the calyx or flower end; in subsequent broods, however, the larvæ frequently enter the fruit at the sides, more particularly at the point of contact of two apples. They work towards the core of the fruit, and in feeding excavate an irregular cavity. The pips, as well as the flesh of the fruit, may be eaten, and many of the attacked apples fall to the ground long before reaching maturity.

The full-grown larva (Plate 3; fig. 2) is about three-quarters of an inch in length, and is pink or white in colour, with a brown head and eight pairs of legs. The larvæ are full-grown in about a month, and they then leave the fruit to pupate under pieces of rough bark or in cracks in the limbs of the trees or in other spots affording somewhat similar shelter. The brown pupæ (Plate 3; figs. 3 and 6) are about half an inch in length, and in two weeks' time the codling moths emerge from these pupæ. The colour pattern of the greyish-brown moth (Plate 3; figs. 4 and 5), which has a wingspread of about three-quarters of an inch, is broken by a patch of copper-coloured scales of a metallic tint. Two broods of codling moth occur regularly in Queensland each year, and the pest overwinters in the larval stage, moths emerging therefrom about the time the petals commence to fall.

Control.

For many years the standard procedure has been to spray with arsenate of lead for the control of this very serious pest, applying a calyx spray as soon as the petals have fallen and before the calyx cup has closed (Plate 3; fig. 7). The calyx spray has been regarded as being essential, several cover sprays following it at intervals of two or three weeks. The spray has generally been applied at the rate of 1½ lb. of the powder form of arsenate of lead to 50 gallons of water. During recent years, however, the presence of injurious quantities of arsenical spray residues has been the cause of much anxiety in various apple-producing countries, and a search has been made for other sprays which do not possess the undesirable features of arsenate of lead. Recent

* *Cydia pomonella* L.

DESCRIPTION OF PLATE 2.

INSECT ATTACK ON FRUIT TREES AND VINES.

Fig. 1.—Fruit fly infested apple.
Fig. 2.—Fruit fly sting on passion fruit.
Fig. 3.—Codling moth infested apple.
Fig. 4.—San José scale infested pear.
Fig. 5.—Woolly apple aphis infested twig.
Fig. 6.—Phylloxera swellings on grape vine root × 2.

First five figures half natural size.

departmental experiments have shown that the nicotine sulphate and white oil spray mentioned in the discussion on the Queensland fruit fly gives much promise as a suitable alternative spray, one point still in doubt being a possible cumulative ill-effect of the application of an oil spray at frequent intervals. These experiments have also shown that other non-arsenical sprays, *e.g.*, potash soft soap, and colloidal sulphur and potash soft soap, some of which are cheaper than the nicotine sulphate-white oil mixture, may prove suitable alternatives. As indicated, the last-mentioned spray has given very promising results as a fruit fly repellent in several apple orchards, thus showing possibilities as a useful dual purpose spray. Unfortunately, it is expensive.

The use of strong cloth bandages, prepared by folding a 10-inch wide piece of cloth to form a double layer 5 inches wide, constitutes another important control measure. These bandages should be placed on the trees in the Stanthorpe district late in October, each being tightly wound round the tree and retained in position by means of a nail. Many of the larvæ on leaving the fruit to pupate will congregate under the bandages, and, if these are examined at intervals of about ten days, the assembled codling moth larvæ and pupæ can be destroyed. Success in the use of these bandages in large measure depends on steps having been taken to eliminate other sheltered spots which might be chosen for pupation. Hence it is important that any cracks or cavities in the branches of the trees be closed up by clay or putty, and loose bark should be scraped off the limbs to eliminate shelter spots.

Chemically treated corrugated cardboard strips have in recent years been used to some extent instead of the ordinary cloth bandage. The important advantage of this new style bandage is that most of the codling moth larvæ assembling thereunder die, thus rendering the frequent inspection of the bandages unnecessary and thereby reducing the amount of labour involved in this control measure. Corrugated cardboard bandages impregnated with beta-naphthol dissolved in kerosene were successfully used in a departmental experiment at Stanthorpe without any injurious effect on the bark. Some bark injury associated with the use of chemically treated bandages has, however, been recorded in New South Wales, but not at Stanthorpe.

Trapping codling moths by the use of molasses and water lures has been the subject of investigation during recent years, but such trapping gives little promise of being in itself a worth while control measure. It may, however, possess some value as an indicator of the most effective time at which to apply the sprays.

All windfalls should be collected and destroyed, and the flooring boards, packing benches, and empty cases in the packing-sheds should be carefully inspected for sheltering larvæ, which may be killed by boiling water if they cannot be otherwise destroyed because of inaccessibility. Larvæ pupating in autumn at or just below soil level at the butt of the trees should be destroyed to reduce overwintering.

Finally, if a very heavy crop of apples has been set, judicious thinning may lead to an improvement in codling moth control.

SAN JOSE SCALE.*

The trunk, branches, leaves, and fruit (Plate 2; fig. 4) of infested trees in the Stanthorpe district may be attacked by San José scale, and a pink or deep red discolouration is usually associated with its

* *Aspidiotus perniciosus* Comstock.

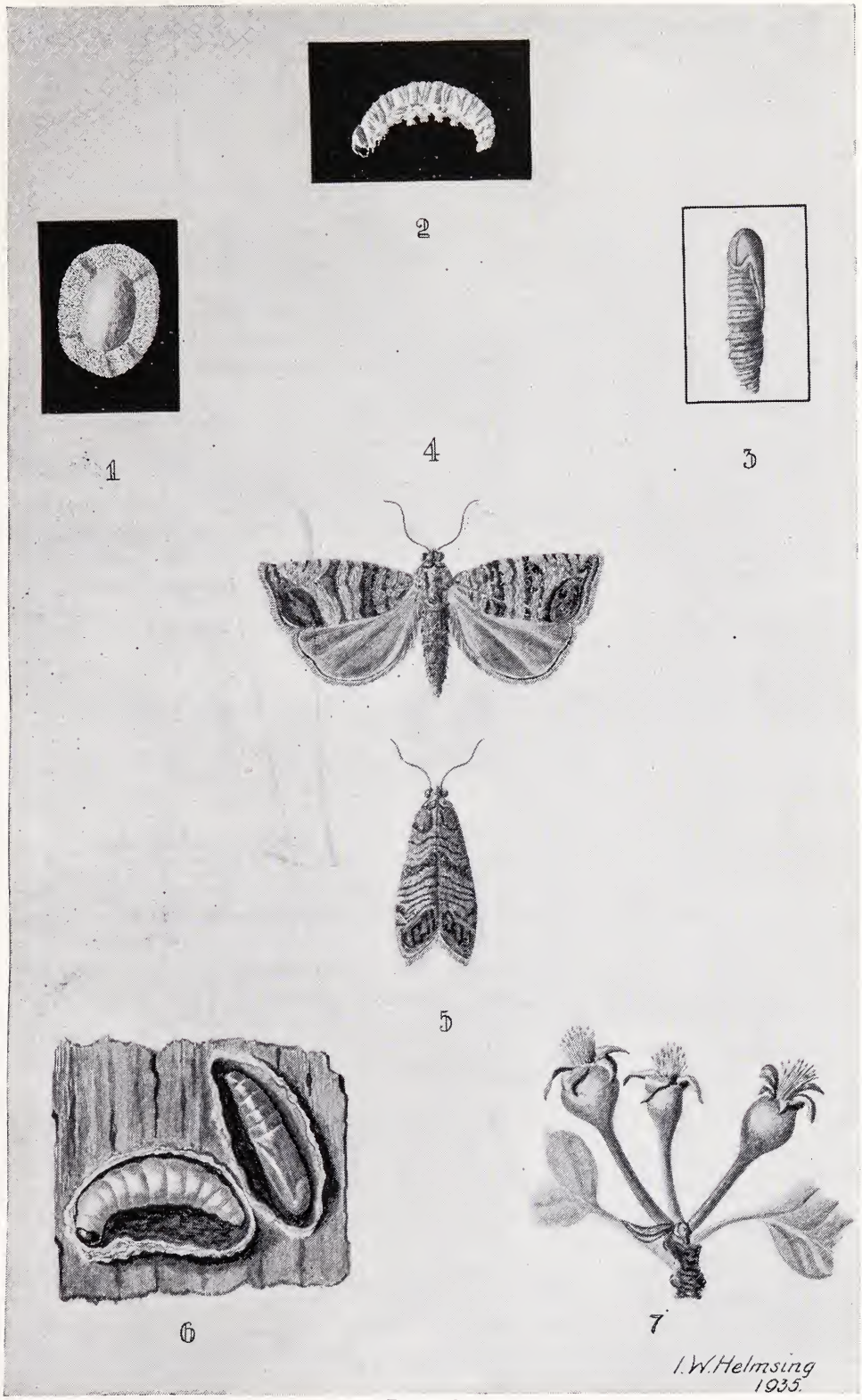

Plate 3.

CODLING MOTH.

Fig. 1.—Egg × 15.
Fig. 2.—Larva × 4.
Fig. 3.—Pupa × 4.
Fig. 4.—Adult with wings spread × 5.
Fig. 5.—Adult with wings folded × 5.
Fig. 6.—Larva and pupa in silken cocoons × 2.
Fig. 7.—Correct time for first spray.

Face page 24.

presence. Unlike the Queensland fruit fly and the codling moth, this pest inflicts injury by sucking the plant sap, thereby weakening its host. All the common deciduous fruit trees are subject to attack, and it is regarded as the most destructive scale insect enemy of such trees.

Life History and Habits.

The scale-covering of the female is circular, slightly convex, and greyish-brown in colour, and conceals the insect proper, which is soft-bodied, yellowish, circular, and legless. Unlike the female, the male is sheltered under a scale only when young, and the adult male is a free-living very delicate insect possessing a single pair of wings. The scale of the male is somewhat smaller and is more elongate in shape than that of the female. After mating, the female gives birth to living young, which are lemon-yellow in colour. These young or crawlers migrate from the protection of the mother's scale in search of a suitable feeding spot, at which they settle down. They then commence feeding, form protective scales, and eventually lose their legs. The rate of multiplication of this insect is very rapid, and if neglected the bark of infested trees soon becomes smothered in a mass of scales which give it a greyish scurfy appearance.

Control.

Fortunately, San José scale can be adequately controlled by spraying during the winter months when the trees are fully dormant. Oil sprays are frequently employed for that purpose, being used at a strength of 1 gallon of oil to 20 gallons of water. These oil sprays will also control red mite, but are not so satisfactory against the green peach aphis and black peach aphis. Lime sulphur may also be satisfactorily employed for San José scale control at a strength of 1 in 10 (2·12 polysulphide), the lime sulphur, of course, being additionally helpful in the control of certain fungous diseases. The third type of spray which may be used against San José scale is a tar distillate wash, this being applied in the case of pip fruits at a strength of 4 gallons of distillate to 100 gallons of water, and in the case of stone fruits at a strength of 3 gallons of distillate to 100 gallons of water. The tar distillate spray at the strength recommended for use on stone fruits is not generally considered to give as satisfactory a degree of control of San José scale as oil sprays and lime sulphur, but it possesses the additional merit of giving a good degree of control of green peach aphis. The tar distillate spray must be applied while the trees are completely dormant, otherwise the swelling and opening buds will be injured. The strengths just quoted in the case of the tar distillate are those recommended by the manufacturers of the brand at present marketed in this State. Should other brands come on the market, attention should be paid to the directions given with respect to strength of application; indeed, this recommendation is applicable to all proprietary lines of insecticides. From what has just been said it is obvious that the choice of the particular spray to be used for the control of San José scale will, in a considerable measure, depend on the presence on the scale-infested trees of other pests and diseases requiring attention during the winter months.

WOOLLY APPLE APHIS.*

Like the San José scale, the woolly apple aphis feeds by sucking the sap of its host plant, typically feeding in colonies on both the roots and branches, thereby producing very characteristic gall-like malformations (Plate 2; fig. 5). For all practical purposes it can be regarded as confining its attention to apples. The aphis is slaty-blue or plum-coloured, but the colour is largely masked by the production of a white wax secretion which covers the body; this insect also produces long waxy threads, a feature which has been responsible for the common name woolly apple aphis.

Control.

This aphis is potentially a very serious pest of the apple, but it is now of much less importance than was previously the case in Queensland. Trees are now worked mostly on stocks which are resistant to woolly aphis, and for this purpose the Northern Spy and Winter Majetin have been generally used. Thus the root infestation is adequately dealt with, but the aboveground colonies have still to be handled. Nicotine sulphate sprayed under high pressure gives a reasonable degree of control, but the spraying has to be repeated at frequent intervals during the summer months. This is very costly, both in time and spray materials, but, fortunately, a considerable degree of biological control has been established in recent years as a result of the introduction of a wasp parasite which breeds on the aphis. This beneficial insect† checks the infestation for most of the year, but two applications of nicotine sulphate are desirable to assist it—one in spring, and the other in late autumn. Prunings on which the aphis is heavily parasitised may be saved with beneficial results in an increase in the numbers of the parasite present early in the season.

GRAPE PHYLLOXERA.‡

The grape phylloxera is closely allied to the aphids and may be found on both the roots and the leaves of the grape vine. Fortunately, the root-infesting form is the only one known in Queensland, and, furthermore, it is confined to one small area in the State. The soil requirements of this species are such that it is not considered likely to become a serious menace, even if it does reach the main grape-producing districts of Queensland.

Life History and Habits.

The life history of this pest is a very complicated one, which varies in different countries. Owing to its restricted occurrence in this State it has neither been possible nor necessary to study the life history in detail. The small yellowish eggs, which are found on the roots, are oval in shape, and the yellowish adult root-inhabiting form is about one-twenty-fifth of an inch in length. Colonies of this species have the appearance of small yellowish patches of particles somewhat resembling curry powder. Typical swellings (Plate 2; fig. 6) are produced on the roots as the result of the feeding of the phylloxera, and root decay rapidly ensues, followed by stunting of the vine, which may eventually die.

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* *Eriosoma lanigerum* Hausm.

† *Aphelinus mali* Hald.

‡ *Phylloxera vitifoliæ* Fitch.

Control.

Soil fumigation and the flooding of infested vineyards have been employed elsewhere for the control of this potentially serious pest, but neither of these control measures are practicable under Queensland conditions. Here, as is usually the case elsewhere, the most practical control measure is to graft the desired grape-bearing variety on resistant root stocks, of which quite a number are available.

GRAPE VINE LEAF BLISTER MITE.*

The foliage of grape vines in Queensland occasionally shows rather characteristic malformations as a result of the presence of the grape vine leaf blister mite. The condition produced by the feeding activities of this species is generally referred to as erinose, but it is also occasionally called the leaf pock disease.

Life History and Habits.

This very small four-legged white mite possesses an elongate slightly cone-shaped body which tapers from the head end. It hibernates under the bud scales during winter and commences feeding when the foliage reappears. Feeding takes place on the under surface of the leaves, and the infested portions of the leaves become malformed. A number of swellings are observed when infested foliage is viewed from above, but when viewed from below it will be noted that there is a depression on the under surface corresponding to each swelling on the upper surface, and each depression is clothed with a felt-like mass. This felt-like mass is at first light-green in colour but eventually becomes dark-brown. It is produced as a reaction to the feeding of the mites on the leaf tissue and consists of a very large number of thread-like outgrowths from the leaf. The mites breed and feed within the shelter of these outgrowths, and a considerable number of generations occur each season.

Control.

This mite is now regarded as being of very little consequence in commercial vineyards and, indeed, it is rarely observed therein in any degree of abundance. No experimental work has been carried out on its control in Queensland, but it seems probable that dusting with sulphur will exercise some measure of control should the mite show signs of becoming abnormally abundant on the foliage. Indeed, the practice of dusting with sulphur for the control of powdery mildew of the grape vine is probably in part responsible for the fact that the vine leaf blister mite is normally of no consequence in Queensland vineyards. However, should it become abnormally abundant in a vineyard, consideration might be given to spraying the vines with lime sulphur late in winter, using the spray at a strength of 1 in 10 (2·12 polysulphide).

BLACK PEACH APHIS.†

The black peach aphis feeds on the roots, twigs, and foliage of the peach, the results of its presence being most obvious on the infested above-ground portions, which become shrivelled and stunted, ending in failure of the crop in extreme cases. The root infestation also has an adverse effect on the general health of the tree.

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* *Eriophyes vitis* Land.

† *Anuraphis persicæ-niger* Smith.

Life History and Habits.

The full-grown aphis is about one-sixteenth of an inch in length, and is black in colour, the only pattern being formed by yellowish markings on the legs. The immature aphis is somewhat lighter in colour, but it otherwise resembles the wingless adult. During winter and early in spring some of the root-feeding aphids, which are wingless, emerge from the soil, feed voraciously on the tender young growth when it appears with the advent of warm weather, and multiply rapidly. Winged forms are subsequently produced, and these migrate to other trees to spread the infestation. Towards the end of the season the surviving aphids return to the soil.

Control.

Oil sprays and tar distillate washes used during the winter months on deciduous fruit for the control of San José scale will also be of value in dealing with whatever black peach aphis is on the aboveground portions of the tree in the Stanthorpe district. When the black aphis shows up on the young shoots in spring the trees should be sprayed with nicotine sulphate.

GREEN PEACH APHIS.*

The green peach aphis is another important pest in the Stanthorpe district, where it is responsible for much injury to the leaves, blossoms, twigs, and young fruit. The early brood attacks the blossoms with a consequential failure to set fruit. The infested leaves become curled and discoloured, and the young wood may be severely injured. The newly set fruit may be attacked and reduced in quality, and may even drop off the trees.

Life History and Habits.

Shortly before the advent of winter the green peach aphis, which is greenish-yellow in colour, lays its very small, black shining eggs on and in the vicinity of the buds or in the crevices of the bark of peach trees. These eggs overwinter, and at the approach of spring the aphids hatch therefrom, and by the time the buds have burst, these aphids, which are wingless, have commenced to feed voraciously and to breed rapidly, giving birth to living young, which are yellowish-green in colour. The material injury to the peach is confined to this period of the year, for early in summer the winged aphids appear, and these migrate to other cultivated and wild plants, on which they breed till autumn. In the autumn winged forms fly to the peach trees and produce a further generation, which lays the overwintering eggs described at the beginning of this paragraph, this being the only time of the year at which eggs are laid.

Control.

Tar distillate washes applied during the fully dormant period at a strength of 3 gallons of distillate to 100 gallons of water, as discussed when considering the control of San José scale, will kill the overwintering eggs of the green peach aphis.

RED MITE.†

The red mite commonly attacks deciduous fruit, but it is not a serious pest in the Stanthorpe district. This mite feeds on the foliage, and where infestation is severe the attacked leaves have a sickly yellow appearance.

* *Myzus persicæ* Sulz.

† *Bryobia prætiosa* Koch.

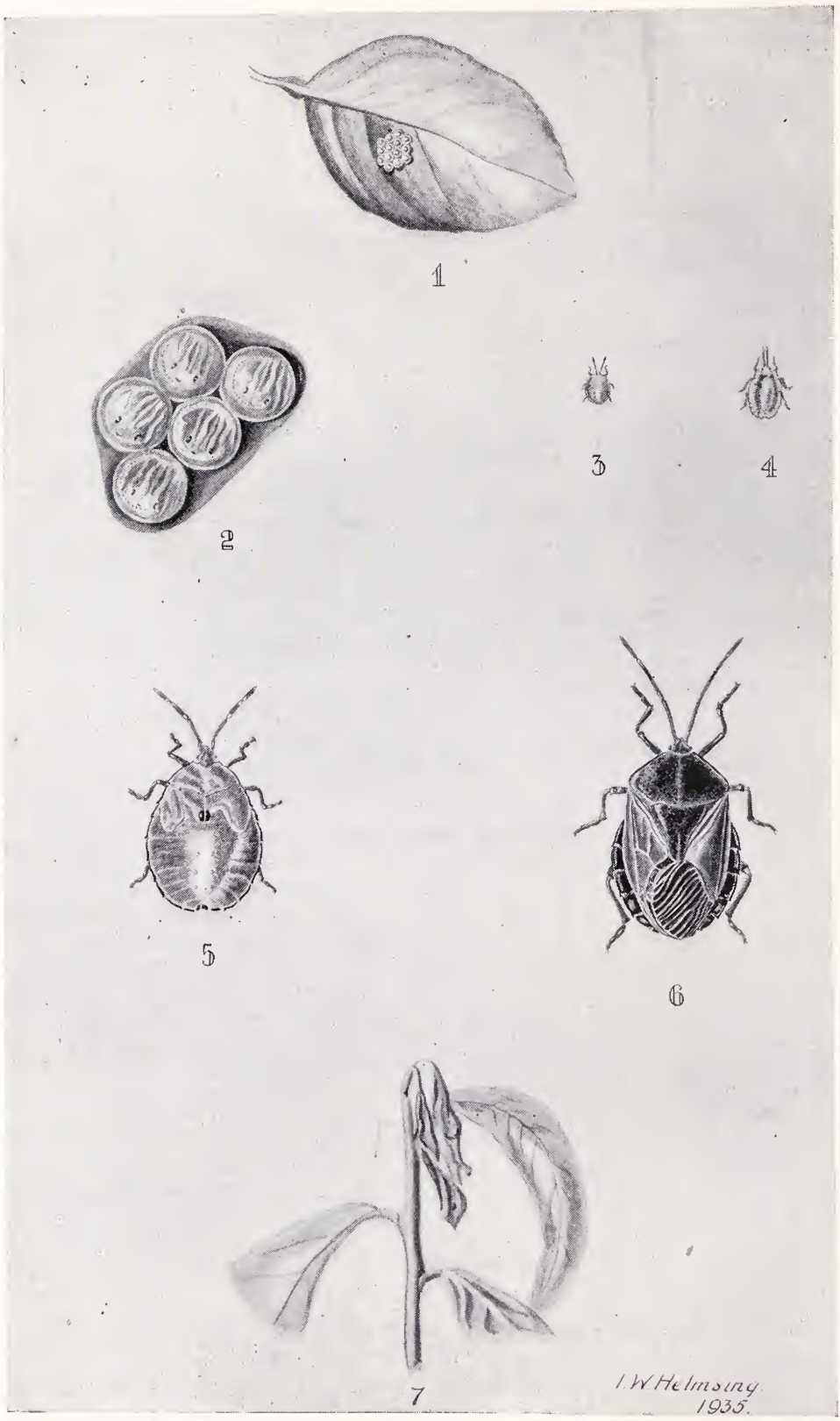

Plate 4.
BRONZE ORANGE BUG.

Face page 29.

Life History and Habits.

The overwintering eggs, which are very small and are red in colour, are laid in the autumn in large numbers on the bark, the favourite oviposition sites being the fruit spurs and fruit scars. Early in the spring the mites hatch from these overwintering eggs, their emergence coinciding with bud-burst. Breeding and feeding on the foliage continues throughout the season. The newly-emerged mite is an extremely small, active, red, spider-like species, possessing three pairs of legs. After the first moult, however, it assumes the typical reddish-brown colour, and at the moult it acquires a fourth pair of legs, the front pair of legs being distinctly longer than the other three pairs.

Control.

Normally, one application of an oil spray at a strength of 1 to 20 during the fully dormant period will kill the overwintering eggs and establish a reasonable degree of control of this pest. Hence, if oil sprays are used for the control of San José scale, red mite should be of little consequence in deciduous fruit orchards.

BRONZE ORANGE BUG.*

The bronze orange bug is one of the commonest pests of citrus in the humid coastal districts of this State, and is particularly destructive on the Blackall Range and Tamborine Mountain, where it has been estimated to be responsible for a substantial reduction in the potential yield of many infested orchards. This pest feeds chiefly by sucking the sap of young twigs, but flower and fruit pedicels and young fruit may also be attacked, the fruit and flowers falling to the ground soon after the bugs have fed on them. The tender young twigs wilt (Plate 4; fig. 7) and shrivel up shortly after being attacked, and orchards subject to severe infestation rapidly become unsatisfactory commercial propositions for the duration of that infestation and for several years thereafter.

Life History and Habits.

The oval dark-bronze adult bug (Plate 4; fig. 6) is about an inch in length, and is generally first found early in November, the number of adults increasing steadily until midsummer. The bug lays its spherical light-green or almost yellowish eggs (Plate 4; figs. 1 and 2) during the summer months, generally on the undersides of citrus leaves, there usually being fourteen eggs in each cluster. After an incubation period of eight or nine days the small green oval and somewhat convex-shaped first-stage nymphs (Plate 4; fig. 3) emerge. These nymphs remain clustered together, and drop readily to the ground if the tree is jarred. They transform in five or six days to the second-stage nymph (Plate 4; fig. 4), which is lighter green or eventually even greyish in colour, and is also much flatter. These second-stage nymphs scatter over the foliage of the tree, to which they adhere very

* *Rhœcocoris sulciventris* Stål.

DESCRIPTION OF PLATE 4.

BRONZE ORANGE BUG.

Fig. 1.—Egg cluster, half natural size.
Fig. 2.—Eggs about to hatch × 4.
Fig. 3.—First-stage nymph, natural size.
Fig. 4.—Second-stage nymph, natural size.
Fig. 5.—Fifth-stage nymph, natural size.
Fig. 6.—Adult, natural size.
Fig. 7.—Young citrus twig damaged by bug, half natural size.

tenaciously, and it is in this stage that the insects pass the winter in a more or less inactive state. They resume activity in late August or early September, and feed voraciously on the young shoots which should then be appearing. Most of the nymphs have transformed to the third stage by the end of September, while by the end of the following month a large proportion are in the fourth stage, the fifth and final nymphal stage (Plate 4; fig. 5) being reached at a somewhat later date. The third-stage nymph is predominantly green, and in this respect resembles the earlier stages, but in the fourth and fifth stages yellow, pink, and red are conspicuous in the colour pattern. The wing buds also show up prominently in the last two nymphal stages.

Control.

The resin-caustic soda-fish oil spray is very effective for the control of this pest, and it should be applied late in March or early in April—i.e., immediately after the insect has transformed to the second nymphal stage. If it is efficiently applied at that time a mortality rate as high as 98 per cent. may be achieved, and the important point is that control is established before the insect has done any appreciable damage, because in the first and second nymphal stages its presence is of no consequence.

Where spraying is not adopted much good can be achieved by sharply jarring the branches of infested trees by means of a padded mallet. If this operation is carried out in the spring months the third and fourth stage nymphs, which then predominate, will fall readily to the ground. The return of these wingless nymphs to the trees must, of course, be prevented, and this can be accomplished by building an earthen cone at the base of each tree. The cone should be about 9 inches high, and should then be partly cut away, leaving a steep face about 6 inches high. As an alternative to the earthen cone a barrier may be formed by a circular strip of galvanised iron seven inches wide. The bugs which have been dislodged from the tree congregate round the base of the earthen cone or galvanised iron barrier, where they can be readily destroyed by a blow-lamp or by collecting and dropping into a tin containing a little kerosene and water.

The jarring of the trees is not free from objectionable features, and wherever it is practicable to do so control should be established by the use of the spray, particularly in view of the fact that this spray also very effectively controls certain species of scale insects.

LARGER HORNED CITRUS BUG.*

The larger horned citrus bug belongs to the same family of insects as the bronze orange bug, but unlike that species it reaches its maximum abundance in the drier citrus districts, such as Gayndah and Rockhampton. Its known native host plant is the native kumquat or desert lime, and in cultivated citrus fruits its order of preference is lemon, mandarin, and orange, although the Late Valencia orange is actually more attractive

* *Biprorulus bibax* Bred.

DESCRIPTION OF PLATE 5.

INSECT ATTACK ON CITRUS.

Figs. 1 and 2.—Branch tunnelled by citrus branch borer.
Fig. 3.—Root attacked by citrus root bark channeller.
Fig. 4.—Lemon damaged by larger horned citrus bug
Fig. 5.—Leaf attacked by citrus leaf-eating weevil. All figures half natural size.

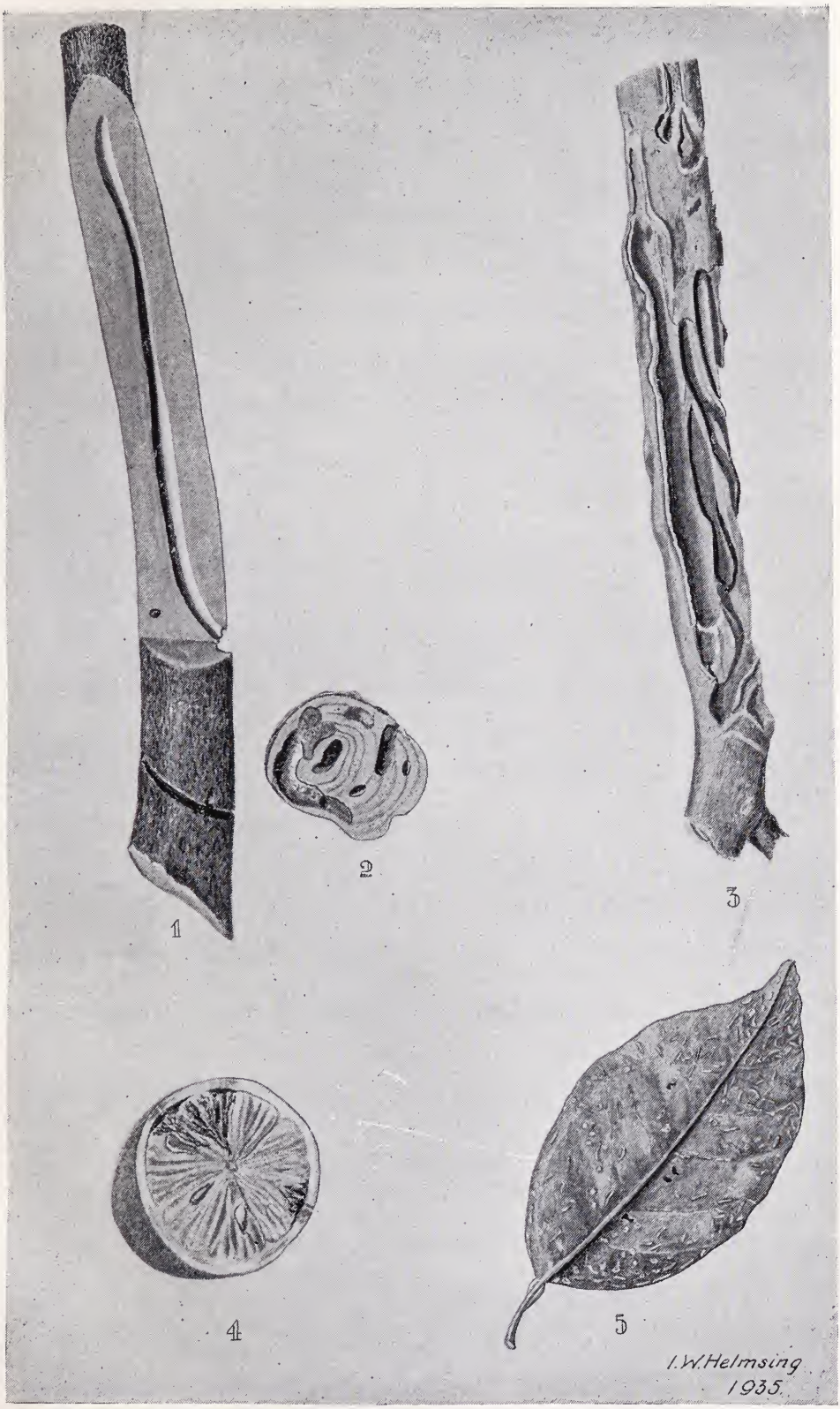

Plate 5.
INSECT ATTACK ON CITRUS.

Face page 30.

than the King of Siam mandarin. In extreme cases 90 per cent. of a lemon crop has been lost as a result of larger horned citrus bug attack, while it has been estimated that even in an average orchard, where systematic attention is given to the hand-picking of the bug, a normal loss of citrus fruit would be from 15 per cent. to 20 per cent. The bug feeds on the fruit, the rind of which is pierced in order to obtain the necessary liquid nourishment. The size of the fruit most favoured is 1½ to 2 inches in diameter, and much of the fruit falls very shortly after attack, the time elapsing between attack and falling depending largely on the variety and size of fruit. The attacked fruit (Plate 5; fig. 4) is partially or completely dried out, while gumming is usually associated with attacks on lemons, and may also occur in oranges.

Life History and Habits.

The elongate-oval green adult bug is about three-quarters of an inch in length, a most important distinguishing feature being the presence of two sharp spines, one on each side of the anterior portion of the body. An allied green bug,* occasionally designated the lesser horned citrus bug, also occurs on citrus. It is, however, smaller than the more important species now under consideration, its spines are much less conspicuous, and, furthermore, it possesses reddish markings which are not present in the larger horned citrus bug. These differences in structure and colour should enable the reader to separate the two species. The larger horned citrus bug overwinters in the adult stage, and with the approach of warmer weather in September egg-laying commences. The pearly-white spherical eggs are generally laid in batches on the fruit and foliage, the number in a completed batch varying from six to thirty-two. The incubation period ranges from three to seven days, and is followed by five nymphal stages, in which growth takes place accompanied by the usual moults between stages. Development is sufficiently rapid to permit of the completion of four generations each year, thus offering a marked contrast to the bronze orange bug, in which there is only an annual generation. A most important practical point in connection with the life history of this insect is the fact that it apparently migrates at the beginning of each generation from the native kumquat, on which it feeds and breeds in the drier districts of the State, to cultivated citrus, migration taking place in spring, early summer, midsummer, and February.

Control.

With the knowledge recently acquired by Departmental entomologists, the effective control of this very serious citrus pest is quite practicable. Owing to the bugs' habit of migrating at the commencement of each generation, however, the control recommendations are a little more complicated than is usually the case, and readers who are engaged in commercial citrus-growing in the drier areas of the State are accordingly advised to obtain a copy of the Departmental bulletin dealing with the pest in order to acquaint themselves with fuller details than can be given in such a publication as this. The following discussion, based on the requirements of the Gayndah district, will, however, serve for present purposes as an outline of the course of action to pursue.

In an orchard in which lemons are grown, all citrus trees other than the lemons should have their mature or second-crop fruit removed as

* *Vitellus antemna* Bred.

early in spring as is practicable, and if possible that should be accomplished by the end of August. This will have the effect of attracting all adults, both those already in the orchard and migrants, to the lemons, thus considerably reducing the number of trees requiring attention in most orchards. Hand-picking in the early morning or late afternoon, following the arrival of the migrating bugs, which is generally spread over a fortnight, should be sufficient at this time, but if the numbers present are unexpectedly large, fumigation should be carried out, preferably in November, at which date a reasonably good control of scale insects will also be obtained. For economic reasons it may not be practicable to remove all the mature or second-crop fruit as just recommended, and if that is the case an effort should at least be made to harvest the attractive mandarin varieties. The more mature fruit on the oranges can then be kept under regular observation, and the bugs, which are attracted to late or second-crop fruit during the spring months, can be disposed of by hand-picking.

The measures just outlined should account for the spring generation, and, if they have been efficiently carried out, no action should generally be necessary for dealing with the early summer generation in December. As a rule the migrants of this generation are few in number and parasites are usually very active on the eggs. If the number of bugs, is, however, unexpectedly large and the early laid eggs, after their development has been watched, are found to be but lightly parasitised, the bugs can be hand-picked or, if weather conditions are sufficiently cool to permit of its use, they can be sprayed with the resin-caustic soda-fish oil spray. Fumigation, instead of spraying, should be employed at this stage only if unavoidable, and then at half strength, followed by the collection of the fallen bugs. As indicated, however, generally no action should be necessary.

Passing now to January, the month in which the midsummer migration is in full swing, fumigation with calcium cyanide should be carried out when the migration has eased off. So far, experience indicates that towards the middle of January is the most appropriate time for the fumigation, which must, of course, be carried out before the bugs commence egg-laying, but not before the migration has ceased. The trees furthest from the source of infestation should be treated first, gradually working up towards the source. The fumigation should be completed as rapidly as possible in order to reduce to a minimum the dispersal of the bugs from untreated trees to those that have been fumigated and freed from infestation.

If the recommendations made in the preceding paragraphs are carried out, no further control measure should normally be necessary. Occasionally, in the event of a prolonged migration leading to abnormally heavy infestation, a second fumigation may be called for at not less than six days nor more than thirty days from the first fumigation discussed in the preceding paragraph. When the double cyaniding is necessary, the second fumigation should be at half strength. The bugs brought to the ground by a half strength fumigation should be destroyed mechanically, a procedure that is unnecessary when the full dosage is used for, in the latter case, there is a high mortality in the bugs.

BLACK PASSION BUG.*

The adult black passion bug occasionally migrates to citrus and feeds voraciously on the fruit, causing a very heavy fall thereof. Fortunately, its attacks are generally concentrated on a few trees, thus appreciably simplifying the problem of control.

Life History and Habits.

This insect is a dull-black rather elongate bug about three-quarters of an inch in length, the prevailing colour being broken by a large number of conspicuous reddish spots on the underside of the body, a transverse band of similar colour also occurring on the upper side just behind the head. The relatively brief life history is completed on various species of plants belonging to the passion fruit and pumpkin families. It has been recorded as attacking the following economic plants:—citrus, passion fruit, pumpkin, choko, tomato, and banana. This species characteristically feeds on well-advanced fruit only, immature fruit being left untouched.

Control.

Migration to citrus, on which this pest does not breed, generally takes place in April and May, when cool or even cold mornings are experienced. After the ground under infested trees has been cleared of weeds and loose soil, the bugs can therefore be brought down by banging the trees with a padded mallet in the early morning or late afternoon, when they are sluggish. They can then be swept up from the ground and flung into a tin containing water and a little kerosene and thus destroyed. Readers will be interested to know that the resin-caustic soda-fish oil spray gave a kill of 70 per cent. of the adults in a preliminary experiment during the last outbreak of this pest. In view, however, of the success of the banging system, the expense of spraying does not appear to be warranted unless some other pest can be effectively controlled at the same time.

CITRUS ROOT BARK CHANNELLER.†

The citrus root bark channeller is a pest in the Maroochy, Tamborine Mountain, and Mary Valley districts, where it feeds on the roots of citrus while in the larval stage. Trees of all ages are attacked, although the damage is generally, but not invariably, most pronounced in old trees.

Life History and Habits.

The study of the life history of this soil-frequenting species has proved very difficult, and gaps in the knowledge requisite to effective control still exist. The insect is a typical small black weevil about a quarter of an inch in length. The season of the year during which it lays its eggs and the manner of their deposition are not yet known. However, the creamy-white, legless larva appears, and when full grown measures one-third of an inch in length. The larva feeds in channels under the bark, usually on the lower side of the root. Attacks may extend over several years and involve a number of insect generations. In such cases the bark is almost totally destroyed along the roots for several feet from the trunk (Plate 5; fig. 3). The citrus root bark channeller rarely attacks deeply situated roots, and as the channels to some extent follow the length of the roots complete girdling is rare. The

* *Leptoglossus bidentatus* Montr.

† *Pseudomydaus citriperda* H.T.

attack is naturally reflected in a marked lowering of the vitality of the infested tree, which may eventually succumb or be severely attacked by fungous parasites. When full grown the larva transforms to the resting pupal stage from which the weevil subsequently emerges.

Control.

The first step in the control of this pest is the restoration of the full vigour of infested trees. Hence, if there are any unfavourable environmental conditions, these should be eliminated in so far as it is practicable to do so. This action should be accompanied by the application of suitable fertilizers, for it has been demonstrated that such application will have a very beneficial effect in restoring the vigour of the trees. Methods for protecting the trees from attack are still being investigated, but the available information does not yet warrant definite recommendations other than those already discussed.

CITRUS LEAF-EATING WEEVIL.*

Very extensive damage to foliage occurs in citrus orchards, more particularly on the Blackall Range, as a result of the presence of large numbers of a beetle known as the citrus leaf-eating weevil. Numerous small areas of leaf tissue are destroyed (Plate 5; fig. 5), and the consequent reduction in the effective leaf surface leads to a definite weakening of the attacked tree. The young fruit may also be injured if the insects are numerous during the spring months.

Life History and Habits.

Practically all that is known about this pest is the fact that the economic damage is caused by the weevil itself. The insect is a typical greyish-brown weevil about one-eighth of an inch in length, and is definitely known to fly, this being one of several features which serve to distinguish the insect from the dicky rice weevil of New South Wales, a well-known pest of citrus in that State.

Control.

Under the circumstances, little can be said about the control of this insect. This is definitely one of the important citrus pests requiring further investigation, and its control will not be placed on a really satisfactory basis until a great deal more is known of its life history than at present.

CITRUS BRANCH BORERS.†‡

Two species of branch borers frequently attack citrus, the commoner† being a greyish-brown or brown beetle about an inch and a-quarter in length and less than a quarter of an inch in breadth. The colour scheme of the other‡ is also greyish-brown, but it is a much stouter-bodied insect, being roughly cylindrical, whereas the commoner species is slender and flat. It measures an inch in length and is about one-third of an inch in breadth. Both species possess feelers extending from the head to or beyond the end of the body.

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* *Eutinophæa bicristata* Lea.

† *Uracanthus cryptophagus* Oll.

‡ *Symphyletes sodalis* Pasc.

Life History and Habits.

Little is known about the life history of these beetles except that their larvæ bore in the twigs, branches, and trunks of citrus, the commoner species showing a marked preference for the twigs and smaller branches (Plate 5; figs. 1 and 2), while the other borer seems to prefer the larger branches and the trunk of the tree. As is the case with many borers, it is probable that attack does not take place unless there is some predisposing factor such as mechanical injury or weakened vigour associated with faulty nutrition or pest and disease attacks. The common species works along the attacked branch or twig, whereas the other species shows a tendency to work round the infested branch or trunk.

Control.

Infestation should be promptly dealt with, and if it is confined to a small part, the attacked twig or small branch should be removed and the larva destroyed. Such a procedure cannot be adopted in the case of larger branches, but frequently the larva can be reached and killed by inserting a piece of pliable wire through one of the holes formed along the tunnel made by the borer. The larva may also be killed by inserting in the tunnel a small plug of cotton-wool soaked in carbon bisulphide. Before insertion, all holes along the course of the tunnel, with the exception of the uppermost, should be sealed with putty, soap, or clay. The plug is then inserted, the hole sealed, and the gas liberated from the soaked plug will kill the larva if in sufficient concentration. In view of what has been said about predisposing factors, it is desirable to avoid even the slightest injury to the bark, it being well worth while to wear rubber-soled shoes when climbing trees to pick fruit.

FRUIT SUCKING MOTHS.*

Several species of large, handsome moths possess the faculty of being able to pierce the skin of the fruit of citrus, mango, papaw, grape vine, persimmon, custard apple, pineapple, and banana. They suck the juice therefrom and the attacked fruit falls to the ground and quickly rots.

Life History and Habits.

The larva of the commonest species of sucking moth is extraordinarily beautiful, rich shades of brown, black, and white constituting the colour pattern, in which large white and black eye spots are conspicuous. The larva does not attack cultivated plants, but feeds on native creepers in the scrub and on the Indian coral tree. When full grown it transforms to a typical moth chrysalis, and eventually the moth emerges. The moth has a wing spread of three inches and is prettily marked, the hind wings each bearing a broad kidney-shaped, dark-brown patch on an orange background, as well as having part of the wing margin marked by a broad band of similar colour. The fore wings bear less distinctive markings, the scales being brown, green, and white.

Control.

The only method of dealing with these pests is to attract the moths to a lure, such as over-ripe bananas or slices of water melons placed at random in the orchard. This lure can be examined at night by the aid of a torch, and the assembled moths destroyed. Fortunately years may pass without any loss from these pests in the major citrus-producing districts.

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* *Othreis fullonica* L., and several other closely allied species of Noctuidae.

MAORI MITE.*

A species of mite responsible for skin blemishes on citrus has been given the common name of Maori because, when present on oranges, it produces a characteristic dark-brownish discolouration of the rind. The injury to mandarin fruit is accompanied by a similar blemish, but in the case of lemons the infested skin acquires a silvery-grey or almost white appearance, sometimes accompanied by surface cracking. Foliage and bark may also be attacked, more particularly in the case of young trees, dark-brown, irregularly-shaped areas appearing on the attacked leaves. Apart from the obvious reduction in market value of skin-blemished fruit it is believed that severe Maori infestation is accompanied by a reduction in the size of the fruit, which may also fall in some cases.

Life History and Habits.

The mite is an extremely small worm-like creature hardly visible to the naked eye, its yellowish or cream-coloured body tapering towards the posterior end. A characteristic feature of this species is the fact that the body appears to be composed of a series of rings. The very small spherical yellowish eggs are laid either singly or in clusters on sheltered portions of the fruit and foliage. The eggs hatch after a brief incubation period, and the young mites rapidly reach maturity, moulting twice during growth. Surface cells on the infested fruit, foliage, and bark are pierced by the mites which feed on the contents thereof. The life cycle is very brief during the height of a Queensland summer, and a large number of generations are consequently produced each year.

This pest has one feature in common with the banana rust thrips—*i.e.*, the feeding produces no immediate obvious ill-effects and the species is so minute in size that heavy infestation with consequential severe losses at a later date may be taking place quite unknown to the grower unless he keeps a close watch on the trees during the summer months. The presence of Maori mites in considerable numbers does, however, produce a dusty appearance on the fruit, and on observing this warning signal the grower should give serious consideration to the application of control measures.

Control.

The breeding of the Maori mite accelerates appreciably during the month of November, hence it is considered desirable to apply control measures late in that month or early in December. Lime sulphur used at a strength varying from 1 in 20 (1·06 polysulphide) to 1 in 25 (0·86 polysulphide) is the spray generally employed at that time of the year for the control of Maori mite, but the strength may require reduction if the prevailing weather is hotter than is normal during the months in question. Growers who prefer dusting to spraying may use a fine sulphur dust instead of the lime sulphur, applying the dust early in the morning or late in the afternoon. This November or December application of the spray or dust does not necessarily complete the campaign against the Maori mite, and growers are accordingly advised to closely watch their trees from the beginning of January until the middle of March. If the observations indicate the necessity for another application of the control measure, trees should be dusted with a fine sulphur or sprayed with lime sulphur at a strength of 1 in 30 (0·71 polysulphide) or 1 in 35 (0·61 polysulphide), the dust being considered preferable to the spray for the second control application, on account of the possibility

* *Phyllocoptes oleivorus* Ashm.

Plate 6.

RED SCALE.—Showing infestation of fruit, foliage, and woody twigs.

of its having to be repeated because of adverse climatic conditions. When Maori mite is of importance every year, spraying with lime sulphur in late winter at a strength of 1 in 15 (1·42 polysulphide) should be carried out in addition to the two applications just recommended.

RED SCALE.*

Red scale (Plate 6) is of world-wide importance, and occurs wherever citrus in grown in this State, although it shows a marked preference for hot, dry climatic conditions. Hence it is a serious menace in such districts as Gayndah and Rockhampton, whereas under the moist cooler conditions of the Blackall Range this pest is less important. Leaves, fruit, twigs, limbs, and main branches may be attacked, but the limbs and main branches are infested only in the case of open, poorly foliaged trees, for this scale shows a distinct partiality for exposed sunny sites and will not be found in appreciable numbers on the two last-mentioned parts if the tree is carrying a reasonably good amount of foliage. Lemons are more susceptible to this species of scale than any other variety of citrus, mandarins being least affected, with oranges occupying an intermediate position. A further important point in infestation by red scale is that a tree in poor health is much more susceptible to heavy attack than one in normal health. Infestation of the fruit appreciably reduces its quality and entails additional expenditure in cleaning before marketing, such cleaning quite frequently facilitating the incidence of moulds. Heavy infestation of the leaves and twigs soon causes their death, and the host tree may be so weakened as to become an easy prey to other troubles, the combined infestation frequently resulting in the death of older trees.

Life History and Habits.

The circular scale of the female is one-tenth of an inch in diameter and has flattened margins with a slightly raised centre. The greyish parchment-like scale is semi-transparent, and the combined colour effect of the scale and of the insect feeding thereunder on the citrus is to impart a definite reddish tinge, hence the common name. The male scale is elongate in form and is lighter in colour than the scale of the female, and within its protection there is formed the male pupa, from which the very fragile two-winged, light-yellow adult male eventually emerges. The female, on the other hand, undergoes no pupal transformation and remains wingless throughout her whole life. The red scale produces living young, and these shelter under the parent scale for some time. However, when they leave its protection they very quickly settle down, hence wind is of comparatively slight importance in the dispersal of this species. The production of young takes place practically throughout the whole year in Queensland and the life cycle is completed in about two months, there being normally five generations each year

Control.

Red scale can be controlled by fumigation with hydrocyanic acid gas or by spraying during the month of March or the first half of April, using either resin-caustic soda-fish oil or a white spraying oil. The time of application given in this recommendation is dependent on the occurrence of the usual monsoonal rains in February and March, but if these are delayed the red scale position in such districts as Gayndah may become serious before the arrival of the normally appropriate date for

* *Aonidiella aurantii* (Maskell).

control. Fortunately, in such districts citrus is usually grown on irrigated land, and the use of ample supplies of water will be found effective in relieving the position until the arrival of the usual control date.

The recommendation just given applies, of course, to these hotter, drier districts which so markedly favour the red scale. If, however, red scale appears as a serious pest on trees other than lemons in the moist cooler coastal districts, then attention must be given to the health of the tree, and once its health has been restored the red-scale infestation will probably rapidly decline. The application of appropriate fertilizers and the adoption of a sound cultural programme may rapidly restore the health of the tree with a marked effect on the scale population. The use of a white spraying oil may, however, be necessary to give immediate relief.

The preceding remarks must be regarded as being applicable to mature trees, for younger trees are liable to infestation in any district. Heavily-infested nursery stock should not be accepted, but light infestation on trees other than lemons will generally become of little consequence once the trees are established. Young trees may be given light oil sprays after they have become established, or they may be fumigated.

CIRCULAR BLACK SCALE.*

Circular black scale frequently occurs in association with red scale, but it is not nearly so injurious as the latter species. Its feeding does, of course, administer a distinct check to the host plant, but the main objection to its presence arises out of the fact that many of the young scales emerging in late summer settle on the half-grown fruit. This necessitates the expense of thorough cleaning before marketing; but, although the fruit may be cleaned, nothing can eliminate a probable shrivelling of the skin and a delay in maturity in cases where infestation is heavy. Like red scale, this species is most abundant in the hotter, drier districts of the State; but while red scale shows a distinct liking for sunlight, circular black scale is generally most abundant on the somewhat shaded portions of the tree. The foliage may be heavily infested all the year round, and, as indicated, fruit may carry very heavy populations of this scale when half-grown. Woodier parts of the tree are not subject to attack, and even the delicate young twigs generally escape its attention. Older trees suffer more severely than younger trees, and lemons experience heavier attacks than other varieties, although late-maturing oranges may also be severely infested. Mandarins are normally little troubled by this species.

Life History and Habits.

The female circular black scale insect lays eggs which quickly hatch into very small yellow crawlers. These crawlers soon settle down, frequently commencing feeding in close proximity to the parent scale, the scales thereby commonly over-lapping as development proceeds. The scale of the female, as the common name indicates, is circular, and when full size is attained is about one-twelfth of an inch in diameter. It is dark-purple or black in colour, but towards the centre there is a brown band and the margin is grey, this parchment-like scale protecting the actual soft-bodied, pear-shaped insect. The scale of the male is some-

* *Chrysomphalus ficus* Ashm.

what elongate, the male insect corresponding in general with the description given for that sex in the red scale. This species over-winters in the immature stages, and with the advent of spring there is a marked increase in its activity. Four generations occur during the year, a generation being completed in nine weeks during the warmer weather. The young scales of this species predominate in September, November, January, and March.

Control.

Circular black scale can be quite satisfactorily controlled by fumigation or by spraying with resin-caustic soda-fish oil or with white spraying oil. A number of considerations indicate that March or the first half of April is the best season in which to apply control, the application being timed to coincide with the completion of the hatching of the fourth generation. Some slight modification of this recommendation may be necessary if red scale is also present, as is often the case. These two species of scale insects are, of course, controlled by the same insecticides, and the exact time of application for their joint control will naturally be determined by the requirements of the dominant species.

MUSSEL SCALE.*

Mussel scale, although the third citrus scale insect dealt with herein, is actually a very destructive species in the State. It occurs in all citrus districts, but, in marked contrast to red scale and circular black scale, it shows a very decided preference for the moist coastal areas. Fruit, foliage, twigs, and branches even an inch thick may be attacked, although the fruit is not usually appreciably infested until March. Small portions of the tree may be killed as a result of the presence of this scale insect, but in the case of larger infested portions, melanose or some other disease frequently becomes associated with the scale insect, and as a result of their combined attack death of large portions of the tree may and frequently does eventuate. When present on the fruit this scale insect is at first characteristically found at the stem end or at points of contact between fruit, although infestation may ultimately become scattered over the rind. Heavy stem-end infestation of the fruit may lead to its premature yellowing and dropping. This fruit infestation is very difficult to remove, much more so than in the case of circular black scale. Mandarins are normally more heavily infested by this scale than oranges, lemons apparently being the least attractive class of citrus.

Life History and Habits.

As its common name indicates, the protective scale in this species is roughly mussel-shaped, and in the case of the female is rather less than one-tenth of an inch in length. The female scale is originally purple in colour but ultimately becomes brown, there being a lighter area at its anterior end, due to the presence of cast skins. The scale of the male is smaller, lighter, and less curved than that of the female. The full-grown female scale insect is creamy-white and soft-bodied, the last abdominal segment being reddish. It is protected below as well as above, because it possesses a thin white ventral scale. Like the circular black scale, this species lays eggs, and the young crawlers emerging therefrom settle as close to the parent insect as possible, thus producing the dense incrustations of scale insects so characteristic of this species. In summer

* *Lepidosaphes beckii* (Newm).

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I. W. Helmsing 1934.

Plate 7.
WHITE LOUSE.

Face page 41.

a generation can be completed in less than nine weeks, and the available evidence indicates that there are four generations in the year. Egg-laying continues throughout the year, and except, perhaps during February there is no clear-cut succession of generations.

Control.

Infestation by the mussel scale is frequently associated with a poor state of health, due to the presence of other adverse factors, and where that is the case every effort should be made to eliminate such conditions. The attack on normally healthy trees is generally confined to the fruit, and this should be kept under observation during the first quarter of the year. Should signs of appreciable infestation be evident, control should be established, preferably in late summer or early autumn. Fumigation is effective, and resin-caustic soda-fish oil has also given good results in very heavy infestations. White oils do not give the requisite control in heavy attacks except where the infestation at the time of application consists almost exclusively of young scales.

WHITE LOUSE.*

White louse occurs throughout the State, and, although temperature does not appear to be an important factor determining its abundance, there seems to be reason for believing that it prefers dry climatic conditions. All portions of the tree are subject to attack, but infestation generally starts on the trunk near ground level and spreads upwards. The trunk and the main limbs are the portions usually infested, and the bark thereon acquires a hard, dark appearance, accompanied by cracking, which serves as a point of entrance for borers, gumming also being frequently associated with the cracks, particularly near the base of the trunk. Infestation may spread to the twigs, foliage, and fruit on neglected trees deficient in vigour, but the results thereon are not nearly so serious as in the case of red scale and mussel scale. Mandarins are less susceptible to attack than oranges and lemons, and young trees do not usually suffer to any appreciable extent.

Life History and Habits.

Like the red scale, this species produces young crawlers instead of eggs, and these can be found practically all the year round, being yellowish in colour and rather elongate in shape. The crawlers settle down in depressions in the bark, to which they adhere very closely, particularly in the case of the females. The somewhat mussel-shaped scale of the female (Plate 7; fig. 2) is dull-brown with greyish margins, a distinct ridge running along the middle of the parchment-like scale, to which dust particles readily adhere. Hence the female scales, which measure one-sixteenth of an inch in length, are difficult to detect on the bark. The male scale (Plate 7; fig. 4) on the other hand is a very conspicuous white colour, and is roughly rectangular in shape, there being three conspicuous ridges running along the scale, which measures one twenty-fifth of an inch in length. The males are

* *Chionaspis citri* Comstock.

DESCRIPTION OF PLATE 7.

WHITE LOUSE.

Fig. 1.—Male scale on bark × 3.
Fig. 2.—Female scale × 24.
Fig. 3.—Adult female × 24.
Fig. 4.—Male scale × 24.
Fig. 5.—Male pupa × 24.
Fig. 6.—Adult male × 24.

much more numerous than the females, and being much more conspicuous their appearance has led to this species being given the quite appropriate common name of white louse. The life cycle may be completed in nine weeks, there being five generations each year, but there is no clearly defined succession of generations.

Control.

Both fumigation and spraying with lime sulphur or resin-caustic soda-fish oil give a very good control of white louse; but control is generally best accomplished by spraying in the late winter just before blossoming, using lime sulphur at a strength of 1 in 12 (1·77 polysulphide). The preference for lime sulphur is based very largely on the fact that its application is attended by other beneficial results in addition to establishing control of white louse.

PINK WAX SCALE.*

The last citrus scale insect to be discussed herein is the well-known, conspicuous, and widely-distributed species generally referred to as the pink wax scale, a particularly common insect in coastal Queensland. An important feature associated with the occurrence of this species is the fact that it has a very wide range of wild host plants, which frequently carry large populations of the scale, a fact to be taken into account when establishing control. Another feature serving to distinguish this species from the four citrus scale insects already discussed is the fact that it is accompanied by a copious growth of a disfiguring and somewhat injurious association of fungi known as sooty mould, which may form a heavy coating on both the foliage and fruit, the removal of which from the latter entails a considerable expenditure of time. Pink wax scale shows a marked preference for tender tissue; hence colonies of this scale insect are confined to young twigs and leaves, on the latter of which it will be found attached to the midrib or main veins on both surfaces. As a result of the infestation, the size of the fruit is appreciably reduced, and the twigs, the vigour of which has been impaired, may be attacked by mussel scale, which paves the way for melanose infection, resulting in the death of large branches and limbs. Mandarins are distinctly susceptible to pink wax scale attack; oranges are less so; and lemons seldom show signs of infestation.

Life History and Habits.

Eggs are laid by this species. and the reddish crawlers hatching therefrom wander about for some three days before settling down, when they secrete a white, waxy covering which eventually becomes globular in shape and predominantly pink in colour, the length of the adult female scale being about one-eighth of an inch. Owing to the period that elapses before settling down many of the crawlers are carried by the wind into orchards from native host plants, these wind-borne individuals settling mainly on the tips of the tallest trees. There are two generations each year, the first brood appearing generally in November and the second typically early in March.

Control.

The outline of the life history of the pink wax scale shows that young scale insects are present in the orchard at two seasons of the year. These have either hatched in the orchard or migrated from wild

* *Ceroplastes rubens* Maskell.

Plate 8.
Butt of banana plant attacked by banana weevil borer.

host plants in the vicinity thereof. Stress has already been laid on the importance of migration in the case of this species, and control measures should not be applied until the migration has ceased. Egg hatching extends over a period of one month, at the end of which time the earliest emerging scales are about the size of a pin's head. It is therefore suggested that spraying take place when the typical young scales are about that size. Spraying with the soap and washing soda mixture gives a very satisfactory kill of the young scales, but its application should not be delayed longer than necessary to permit of the arrival of the migrating scales, for the older the scales become the more resistant are they to spraying. Control should normally take place in November or early December in the case of the early summer emergence of pink wax scale, while spraying for the late summer brood should be carried out at the appropriate time ranging from late February to late April. The resin-caustic soda-fish oil spray is also very effective against this species, and possesses the advantage of giving quite good results against well-grown scales. The disadvantage is that it cannot be used in very hot weather, and thus can seldom be recommended for use in December.

BANANA WEEVIL BORER.*

The banana weevil borer is the most serious banana pest in Queensland, and the productive life of a plantation may be considerably shortened if infestation becomes severe (Plate 8). The corms may be absolutely riddled by the grubs, as many as thirty-five having been found in one corm.

Life History and Habits.

The pearly-white elongate-oval egg (Plate 9; fig. 1) of the banana weevil borer is one-twelfth of an inch in length, and is laid in the tissue of the banana plant at or near ground level, one egg being inserted in each of the cavities formed by the beetle. The eggs, which are closely sealed in these cavities, hatch out in eight days during the summer months, and the legless, creamy-white larvæ emerging therefrom commence tunnelling in all directions in the corm. The full-grown larva (Plate 9; fig. 2) is half an inch in length, and may complete its growth in little more than two weeks in the warmer weather, although in winter the duration of this stage may be several months. When full grown the larva works towards the outside of the corm and pupates at the end of the feeding tunnel without forming the cocoon so commonly found in the weevil family to which this beetle belongs. The duration of the pupal stage (Plate 9; fig. 3) averages one week, at the end of which period the black, hard-shelled, snouted, half-inch beetle (Plate 9; fig. 4) emerges to feed, mate, and repeat the life cycle.

Control.

This brief review of the life history shows that the borer is completely embedded within the banana tissue during the egg, larval, and pupal stages, the only free-living stage being the adult or weevil. Hence insecticides can be employed against the adult only, and their application must be supplemented by other control measures.

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* *Cosmopolites sordidus* Chevr.

DESCRIPTION OF PLATE 9.

BANANA PESTS.

Banana Weevil Borer: Fig. 1.—Eggs × 4; Fig. 2.—Larva × 4; Fig. 3.—Pupa × 4; Fig. 4.—Adult × 4.

Banana Rust Thrips: Fig. 5.—Larva × 45; Fig. 6.—Adult × 45.

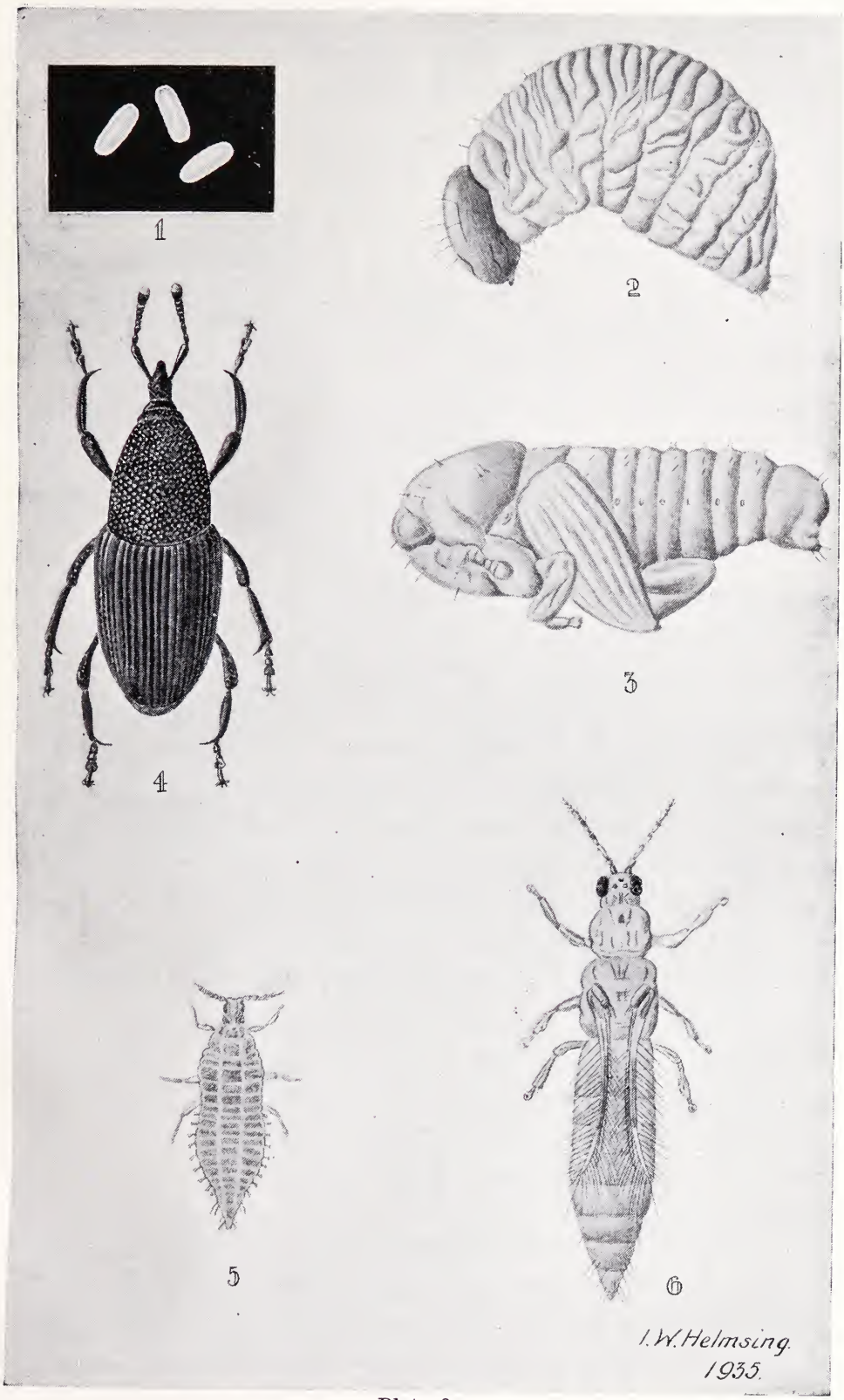

Plate 9.
BANANA WEEVIL BORER AND BANANA RUST THRIPS.

Face page 44.

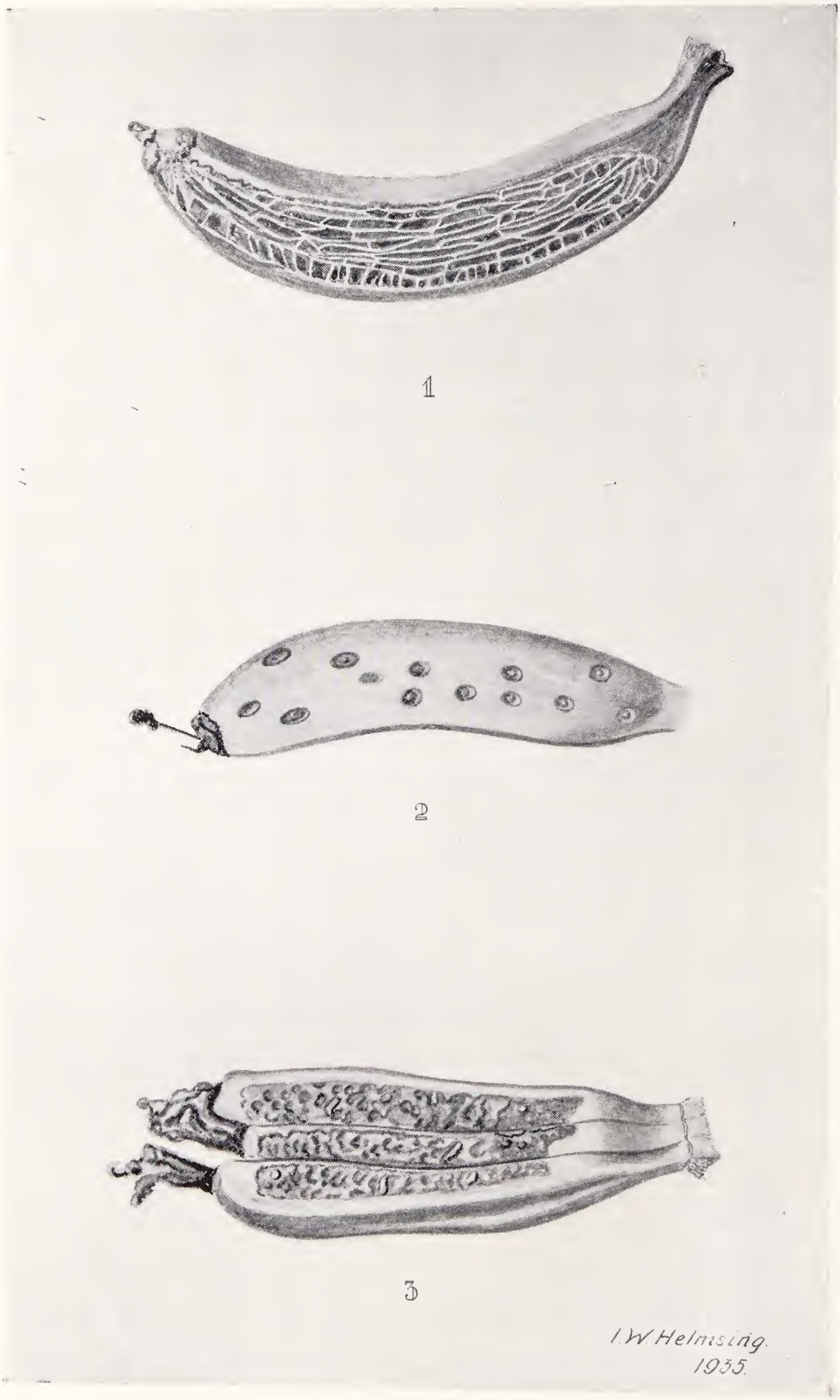

Plate 10.

Fig. 1.—Banana injured by rust thrips.
Fig. 2.—Banana injured by fruit-spotting bug.
Fig. 3.—Fruit-eating caterpillar damage on banana.

Face page 45.

It is obvious that one of the most important measures is to prevent or to minimise the infestation of new plantations; hence only clean suckers should be used in establishing such areas and, if possible, they should be obtained from uninfested plantations. When such is not practicable the suckers should be procured from a lightly infested plantation in which attention has been consistently paid to the control of the banana weevil borer. Very few plantations in Queensland are now free from borer infestation, hence it is usually desirable to pare the corm of every sucker to a depth of one-eighth of an inch. Excessively deep paring should be avoided as being not merely unnecessary but as being actually detrimental to the ultimate welfare of the plantation. Experience shows that unnecessarily deep paring has frequently destroyed the dormant buds required to produce the followers necessary for the maintenance of the productivity of the plantation. The paring of the suckers will eliminate any eggs which may be in the surface tissue, and may also reveal the presence of borer tunnels, and in the latter event the sucker should be rejected. The suckers dug each day should be bagged and removed before nightfall to a sufficient distance to prevent reinfestation by the weevils. Growers are reminded that the planting policy of the Banana Industry Protection Board discusses the securing of suckers, and that particulars of the current planting policy can be obtained from the local agent of the Board.

Infested plantations should be regularly baited, and for this purpose one part of Paris green mixed dry with six parts of flour by weight is the insecticide generally employed. This poison mixture may be dusted on the baits through the finely perforated lid of a half-pound cocoa tin. When desuckering commences the newly-cut surfaces of the parent corms should be dusted with the Paris green and flour mixture, and the butts of the sucker eyes or suckers may be sliced off and replaced in position after being dusted with the poison mixture. Stems from which the bunches have been cut should be chopped down at not more than 6 inches from the ground and split open to facilitate rapid drying, thus rendering the tissue unsuitable for the breeding of the banana weevil borer. The butt left after the cutting down of the spent stem must be poisoned whenever weevil borer is present. This can be accomplished by cutting the butt at or near the level of the ground, thus forming a slab a few inches thick. The cut surfaces should then be dusted and the slab replaced with a small stick or stone between the slab and the remaining part of the butt. The beetles are readily attracted to the baits made as described, but care must be taken to ensure that there is only a thin, even dusting of the cut surfaces. Heavily dusted surfaces will not be attractive to the beetles, while too-lightly dusted baits will permit the beetles to feed without being poisoned. The period of attractiveness of the baits will be considerably prolonged by covering them with a little trash.

BANANA RUST THRIPS.*

The banana rust thrips (Plate 9; fig. 6), which is the second most important pest of the banana in this State, has a wide distribution, ranging from the far North to the New South Wales border. Fortunately, many of the southern districts in which it does occur suffer only slight losses as a result of its presence; nevertheless it is a serious latent danger

* *Scirtothrips signipennis* Bagn.

wherever established, in that it may rapidly assume epidemic proportions. Growers are therefore recommended to take all reasonable precautions to prevent its becoming established in their plantations, and to promptly adopt control measures should it show signs of causing the extensive development of rust.

The skin of fruit which has been extensively attacked by this thrips ultimately develops a typical reddish-brown appearance, and the surface becomes somewhat rough (Plate 10; fig. 1). The skin blemishes may be confined to the points of contact of the individual fruits, but they may involve practically the whole of the surface, which can become badly disfigured and cracked. Severely blemished fruit is usually unsaleable, and even lightly marked fruit is reduced in market value.

The banana rust thrips has, during recent years, been found breeding in a few citrus orchards but fortunately no serious outbreak of the pest has occurred on that fruit.

Life History and Habits.

The very small eggs of this thrips are laid in the plant tissue, being most commonly found on the fruit at the points of contact thereof or under the leaf sheaths. The white or yellow coloured larvæ hatch from the eggs in seven to ten days in summer, and these larvæ (Plate 9; fig. 5) reach their full size of about one-sixteenth of an inch in a similar period. The larvæ then pupate in the soil, and seven to ten days later the slender, golden-yellow adults emerge from the milk-white pupæ. Two pairs of narrow, fringed wings are present in the adult stage, and on each of the forewings there are two definite dark areas. The adults are approximately one-sixteenth of an inch in length.

Control.

Where severe infestation occurs growers should adopt one of the following three alternative control measures each of which, if thoroughly, promptly and correctly applied, is capable of giving a reasonable degree of control under Southern Queensland conditions.

The first control measure consists of dusting the bunches at weekly intervals with a light nicotine dust that floats well in the air and is of reasonably high nicotine content, the nicotine preferably being present as free nicotine, although dusts containing the nicotine in the form of nicotine sulphate can also be used. It is best applied by means of a dust gun, the normal flow of which will usually have to be reduced to prevent the use of unnecessarily large quantities of dust and the accumulation of an undesirable amount of dust residue. Dusting should commence as soon as possible after the emergence of the bunch, and should normally continue for ten to twelve weeks. The dust should be lightly and evenly applied from each side of the bunch, and forced in between the fingers, great care being exercised in the dusting of the top hands, particularly in the case of plants showing symptoms of choking. The bunch stalk from the top hand to the throat should be included in the first two or three dust applications. The bracts should be removed as soon as they are free and the flower end should be broken off. The dusting of wet bunches is undesirable. Usually in plantations infested by the banana rust thrips, dusting is required from December to April, and is financially sound when reasonable prices are being obtained for bananas.

As an alternative the grower may wrap cloaks of 11 oz., *i.e.*, good quality, sugar hessian round the bunches and dust them from the bottom and from any exposed side at fortnightly intervals.

A further alternative is bagging and dusting the bunches, the bags used being the same good quality sugar hessian not less than 27 inches wide and 45 inches deep. The bags are placed on the bunches as soon as possible after their emergence from the throat of the plant and are securely fastened round the bunch stalks, the first dusting being applied either just before or just after bagging. A small hole is provided at the bottom of each bag to permit of dusting at fortnightly intervals. Two weeks later the bags are taken off, the bracts are removed, the flower ends broken off and the bags are replaced. Bags and cloaks should not be removed when dusting, nor should they be removed a few days before cutting to darken the fruit, for such a procedure will usually result in sun scalding. There is some evidence that dusting at weekly intervals for only a month after the bunch is thrown may produce effective control, this being a possible alternative to the fortnightly applications continued throughout the thrips-active period; in both these cases, of course, dusting is being discussed in association with bagging.

Bagging and dusting is an expensive measure but it gives the most satisfactory control of rust, and the bags are responsible for the production of fruit which, apart altogether from the absence of rust blemishes, is very definitely superior to that obtained from unbagged bunches. Cloaking and dusting produces about the same degree of control of rust as does dusting alone, but the cloaking improves the quality of the fruit although not to the same extent as bagging. Cloaking and dusting is intermediate in cost.

The growth of the plants should be stimulated by good cultivation, for it has been demonstrated that bunches thrown by vigorous plants have the hands and fingers well spaced, and that such fruit is less liable to severe rust damage and is easier to treat than the fruit on bunches thrown by less vigorous plants.

Areas free from banana rust thrips infestation should be kept so, and growers in such districts must in their own interests refrain from introducing suckers from other areas unless the latter are similarly free from infestation. In this connection growers are reminded of the fact that each year the Banana Industry Protection Board issues a planting policy, particulars of which are obtainable from the local agent of the Board.

Paring and trimming the suckers as prescribed for banana weevil borer control will reduce the thrips population on the suckers. Dipping such suckers in a solution of one part of nicotine sulphate in five hundred parts of water will also reduce the number of banana rust thrips present on the dipped plants, but neither of these two measures can be relied upon to completely free the suckers from infestation.

BANANA SILVERING THRIPS.*

The banana silvering thrips has in recent years attracted some attention in the banana-growing districts near the New South Wales-Queensland border and in the vicinity of Rockhampton. Only in one case, however, has appreciable loss been observed. The damage is evidenced primarily, as the name suggests, by a silvering of the injured surface of the fruit. In cases of serious infestation (Plate 24; fig. 1) the silvering develops a pale yellow to brown discolouration, speckled darkly with the thrips droppings. Blotchy reddish-brown patches may also be present on mature fruit, the colour in this case being very similar to that caused by the banana rust thrips. Extreme cases have been noted wherein the whole fruit surface was affected, showing the some-

* *Hercinothrips bicinctus* Bagn.

what mottled silver to pale-brown colour together with areas of reddish-brown, deep longitudinal skin cracks appearing in the latter. Silvering may commence anywhere on the fruit surface, and in this respect the banana silvering thrips differs markedly from the banana rust thrips for, in the case of infestation by the latter, feeding and the associated skin blemishes usually commence at the points of contact of the fingers and not on exposed surfaces.

Life History and Habits.

The adult banana silvering thrips is slightly larger than the banana rust thrips, being more than one-sixteenth of an inch in length, and is yellow to brown in colour, the abdomen being noticeably darker than the rest of the body. Two broad brownish bands are present on the pale-yellow fringed hind wings. On the fruit, however, the adult appears definitely blackish, the folded wings showing as a pale-yellow line along the length of the body. The larvæ are yellowish-white in colour, and usually carry a small globule of blackish excrement on the tip of the abdomen. The life history of the banana silvering thrips is very similar to that of the banana rust thrips, the egg stage lasting for ten days in summer while the larval and pupal stages are each completed in a week. This species also attacks passion fruit, choko, cobblers' pegs, and other weeds. Unlike the banana rust thrips, the species now under discussion appears to reach its greatest numerical abundance in the spring and early summer months.

Control.

The measures recommended for the control of the banana rust thrips should be at least equally as effective against the banana silvering thrips, and indeed experience may eventually demonstrate that the number of dustings may be considerably reduced below that considered necessary for the control of the former species. Dusting with a good quality nicotine or nicotine sulphate dust at weekly or fortnightly intervals, the length of the interval depending on the severity of infestation, is one of the recommended control measures. The present available evidence indicates that the period during which dusting may have to be adopted extends from August to November. As weeds are suitable hosts for the propagation of this species they should be kept in check as much as possible. Both the adults and the nymphs can be readily seen on the fruit, and growers on plantations subject to silvering are recommended to keep a close look out for them and to base the initiation and duration of their control programme on the results of their observations.

FRUIT-SPOTTING BUGS.*

Two species of fruit-spotting bugs are occasionally responsible for extensive injury to bananas in the Rockhampton district, more particularly in late summer and autumn, papaws also being subject to slight attack. Both the nymphs and adults pierce the skin of the fruit at all stages of its development, dark circular depressed areas (Plate 10; fig. 2) forming round the feeding punctures, the centre of each puncture being marked by a distinct raised spot. The skin of fruit attacked in the early stages of growth may split across the dark, depressed areas, and the fruit is then unmarketable. If the attack takes place at a later stage in development the result is not so serious, although the fruit at best presents an unattractive appearance. The more destructive of the two species is a rather elongate light-green bug, the other species being dark reddish-brown above and green below. The adults of both species measure half an inch in length.

**Amblypelta lutescens* Dist. and *Dasynus fuscescens* Dist.

Control.

It has not yet been practicable to devote much time to the investigation of the control of pests of localised occurrence, hence control measures for the fruit-spotting bugs are not on a satisfactory basis. It is suggested, however, that some good may be accomplished by holding a bag of mosquito netting over the lower portion of the infested bunch and then sharply jarring the fruit so that the nymphs and adults may fall or fly into the trap thus formed. The bugs collected in the mosquito netting can then be destroyed by dropping into a tin containing a little water and kerosene.

BANANA FRUIT-EATING CATERPILLAR.*

The banana fruit-eating caterpillars belong to several species of moths, but only one is known to occur in plague proportions. The full-grown caterpillars of this species measure 2½ inches in length, and are khaki-coloured with two pairs of black marks on the upper surface of the body. They occasionally occur in enormous numbers, on weeds in or in the vicinity of the plantations, whence they migrate to the bananas, feeding voraciously on the foliage and fruit thereof. The attack (Plate 10; fig. 3) may be confined to the erosion of the skin of the fruit, but the pulp is also frequently eaten, the fruit thus being rendered quite valueless. When such invasions of the plantations are threatened it is suggested that cutworm bran bait be scattered on the ground in front of the migrating caterpillars.

BANANA FRUIT FLY.†

Mention has already been made of the fact that the Queensland fruit fly is not a pest of the banana. Another species, however, does inflict serious losses on this fruit, and is accordingly commonly known as the banana fruit fly. Fortunately this species is confined to those parts of coastal Queensland lying north of Cardwell, in which region it will attack fruit for some weeks before cutting. The essential features of the life cycle of this species are somewhat similar to those recorded in the case of the Queensland fruit fly.

Control.

Some measure of control may be achieved over this species by strict attention to plantation hygiene, involving the collection and destruction of discarded and infested fruit. Furthermore, wild bananas growing in the vicinity of plantations should be eliminated as far as practicable, for it has frequently been demonstrated that the banana fruit fly breeds in the wild bananas. The departmental lure, the formula of which was given when discussing the Queensland fruit fly, has not yet been tested in banana plantations in the North, and it is possible that it may not be effective therein.

PINEAPPLE WHITE GRUB.‡

White grubs not infrequently occur in pineapple soils, and feed on the root system of the plant, which is either badly stunted as a result of the attack or succumbs thereto. Only a small white grub population is necessary to produce appreciable losses in this crop. These white grubs are immature stages of somewhat clumsy, large brown beetles,

* *Tiracola plagiata* Walk.

† *Chætodacus musæ* Tryon.

‡ Generic and specific identification not available.

which fly, feed, and mate at dusk, the day being spent in the soil largely for the purpose of laying soft, glistening white eggs. These eggs hatch after the usual incubation period, giving rise to soft, white grubs, which are furnished with three pairs of legs and possess brown or reddish-brown heads.

Control.

The control of these pests, which are normally of little consequence in pineapple plantations, has not been the subject of a detailed investigation, hence definite recommendations are not at present practicable. In view of the success achieved in soil fumigation with paradichlorobenzene and carbon bisulphide for the control of white grubs in sugarcane fields, it is suggested that satisfactory control is most likely to be achieved along these lines. Preliminary tests to determine the effective and safe dosage of these chemicals, which should not come in contact with the roots of the plants, are of course necessary before the application of the fumigants on a large scale.

PINEAPPLE MEALY BUG.*

The pineapple mealy bug is typical of the group to which it belongs, being a small, soft-bodied somewhat slug-like insect, about one-tenth of an inch in length. Its body is covered with a characteristic secretion of white wax; hence the designation mealy bug. It is generally present in small numbers in pineapple plantations in this State, and occasionally forms considerable colonies on isolated plants or groups of plants. Certain species of ants, and a covering of minute debris, assembled by the ants, are generally associated with the colonies. The pest occurs on the stem and roots below ground, and on various sheltered parts of the above ground portion of the plant, chiefly in the axils of the leaves. It is also sometimes abundant at the bases of the tender heart leaves and at the bases of the fruits, showing a disinclination to occupy exposed parts of the plant. The individuals usually congregate closely together in considerable numbers.

Control.

Although a sparse infestation of mealy bugs is not unusual in Queensland pineapple plantations, there is generally no necessity to adopt measures for the control of this pest. Occasionaly a few heavily infested plants may be encountered, and it is desirable to remove and destroy them and the associated insects so as to prevent the mealy bugs spreading to adjacent plants. In some other pineapple producing countries, however, the pineapple mealy bug constitutes a major problem; fortunately highly efficient control measures have recently been devised for dealing with it. In general these measures are applicable only to large scale plantations, and are directed at the mealy bugs and at the various species of ants associated with them.

FIG BEETLE.†

The larvæ and adults of the fig beetle attack both the fruit and foliage of the cultivated fig and, if present in considerable numbers, can inflict severe damage in a short space of time.

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* *Pseudococcus brevipes* Ckl.

† *Dircema australis* Boh.

Life History and Habits.

This beetle is a sturdily built dull-brown insect measuring one-third of an inch in length, its width being equal to approximately half its length. It lays its eggs in conspicuous clusters, each cluster frequently containing as many as a hundred pale-yellow or cream coloured spindle shaped eggs, each egg being drawn to a fine point which is bent over. The eggs are laid on the foliage and the larvæ hatching therefrom feed voraciously in characteristic clusters on the leaves (Plate 24; fig. 3). Large areas of the surface of the attacked leaves are destroyed, the leaves curling up, withering and falling to the ground. The skin of the fruit is also frequently attacked. The newly emerged larvæ, which possess three pairs of legs, are yellow in colour, but they become darker and the full grown larva is almost black and measures about half an inch in length. The body of the larva bears a number of distinct tubercles and is clad with numerous hairs. The larvæ are full grown in two or three weeks, and they then leave the tree and pupate in the soil or under rubbish at the foot of the tree. The beetles emerge from the pupæ two weeks later and the life cycle is recommenced.

Control.

The larvæ and the beetles of this species both succumb rather readily to an arsenate of lead spray, but the use of such a spray may result in the presence of undesirable and dangerous spray residues on the fruit, when marketed, and arsenate of lead should accordingly not be employed against this pest. Hence experiments are being initiated to determine whether derris sprays, which can be used with safety on trees bearing fruit, will exercise a reasonable degree of control.

Much good can, of course, be accomplished by the mechanical destruction of the conspicuous clusters of eggs and larvæ, particularly if such a control measure is adopted early in the season on the first appearance of these two immature stages of this pest.

FIG LEAFHOPPER.*

The foliage of the edible fig is frequently attacked by nymphs of the sap-sucking fig leafhopper. The attacked leaf margin characteristically curls upwards and exposes the under surface; the midrib and larger veins thereon show light-brownish or rusty coloured spots indicating where the leafhopper had been feeding. This pest, if unchecked, may inflict appreciable foliage injury.

Life History and Habits.

The adult torpedo-shaped leafhopper is about an eighth of an inch in length. Its general body colour is orange, but the eyes are dark-brown or black while three circular spots of a similar colour are situated between the eyes. Similarly coloured areas occur also on the back. The wings are predominantly clear, but smoky dark bands occur on both front and hind margins of the front wings. When disturbed this active insect moves sideways in a very characteristic fashion. The nymphs are fragile little wingless yellow insects with large black or dark-brown eyes. They pass through a series of moults and eventually become full grown. Both adults and nymphs feed by sucking the sap of the attacked foliage.

* *Dialecticopteryx australica* Kirk.

Control.

No departmental experiments have been conducted for the control of the fig leafhopper, but quite a number of growers periodically spray their fig trees with nicotine sulphate at a strength of 1 in 400, and have expressed satisfaction with the results obtained.

STRAWBERRY AND PINEAPPLE THRIPS.*

Not infrequently the fruit of the strawberry has a distinctly russet appearance, both the fleshy fruit surface and the seeds showing evidence of surface abrasion, which eventually develops into minute cracks as the fruit approaches maturity. Plants displaying such symptoms are frequently stunted. A species of thrips, more commonly known as the onion thrips, is often present on the strawberry in considerable numbers, and it is probable, but by no means certain that this insect is associated with fruit injury of the type described. This species is also commonly found associated with pineapples, on which it injures the white tissue at the base of the leaves, more particularly on the tops of the fruit, by feeding thereon and by making egg-laying punctures therein. The former type of injury appears as irregular brown lines, while the latter shows up as minute brown dots. The insect attack in this case is of no consequence in itself, but unfortunately this species is capable of transmitting yellow spot disease of pineapples. Measures for the control of the insect on pineapples, however, are not called for as there are other satisfactory means of dealing with the yellow spot problem.

Life History and Habits.

This species is discussed on page 93 as the onion thrips, and the reader is referred to that discussion for a brief account of the life history of the insect. On the strawberry, both adults and nymphs occur on the flowers and young fruit; they may also be found on the upper surface of the central unopened leaves.

Control.

Nicotine sulphate sprays or nicotine sulphate or nicotine dusts should give reasonable control on the strawberry where conditions warrant some action being taken. Although the position is still somewhat obscure, there is a considerable amount of evidence to the effect that where growers have applied such sprays or dusts, there has been a marked improvement in the treated areas and in the yield therefrom. Some attention will, however, have to be given to the question of possible undesirable spray or dust residues on the marketed fruit, and this is a suitable subject for future departmental investigation.

YELLOW PEACH MOTH.†

The yellow peach moth is an important pest of papaw, maize, cotton, custard apple, citrus and mango, and as its common name indicates, the peach is also a host plant of the larva of this species. The fruit and stem of the papaw is attacked, the larva feeds on the cob and stalk of maize, while in the case of cotton the boll is the part of the plant that is injured, the fruit being the part attacked in the case of the custard apple and the orange. The very small cushion-shaped egg of the yellow

* *Thrips tabaci* Lind.

† *Dichocrocis punctiferalis* Gn.

peach moth is laid on the host plant, and, on hatching, the small caterpillar eats its way into the plant tissue. It becomes full grown in about three weeks in summer, and is then greyish-white in colour, the body being frequently tinged with pink. The caterpillar pupates on the host plant, and the pretty orange-yellow moth emerges after the usual pupal period. The moth has a wing spread of about an inch, and the wings and the body bear a number of conspicuous black spots, a feature that helps to identify this insect.

Control.

The control of this pest is attended by many difficulties, one of these arising out of its wide range of host plants. Some measure of relief may be obtained by eliminating host plants of little or no commercial value, while the destruction of all waste material from crops harbouring this insect should also be productive of some good.

Chapter III.—AGRICULTURAL AND GRASSLAND PESTS.

The brown cutworm is discussed in this chapter primarily as an important pest of cotton, tobacco, tomato, maize, and vegetables, and corn ear worm is considered as a pest of cotton, tobacco, tomato, maize, and lucerne, although, like the brown cutworm, it attacks a very wide range of other economic plants. The plague grasshopper is treated mainly as a pest of grasslands and cereals, while rice weevil is discussed almost exclusively as a maize pest, a brief account of pea and bean weevils being also included. Cotton growers will find that their crop is further represented in this chapter by pink boll worm, rough boll worm, cotton-web spinner, cotton looper, cotton leaf perforator, harlequin bug, cotton stainer, false stainer, cotton seed bug, cotton Jassids, and cotton stalk girdling beetle, but for information on yellow peach moth they will have to refer to page 52, as it is discussed in the preceding chapter dealing with fruit pests. Tobacco is also represented by cluster caterpillar, green tobacco loopers, leaf miner, stem borer, seed harvesting ants, tobacco thrips, and tobacco beetle. Information on nematodes, wireworms, and false wireworm, will be found on pages 98, 107, and 108 respectively, for they are dealt with as general pests. Important pests of grasslands to which reference is made are paspalum white grubs, grass grub, paspalum mealy bug, and army worms.

BROWN CUTWORM.*

Cutworms constitute a large group of insects of practically world-wide importance, their common name being derived from their habit of feeding on the stems of their young host plants at or near ground level, thereby causing the collapse of the attacked plant. The most destructive Queensland species is the brown cutworm, which will be discussed as the representative of the group.

The brown cutworm is particularly destructive to cotton, tobacco, tomato, maize, and vegetables, but it will also attack many other plants of economic importance. As already indicated, young plants or seedlings are attacked at the base of the stem, which may be either ring-barked or nibbled through, thus causing the plant to topple over. Older plants may also be heavily infested, thus leading to their partial or complete defoliation. Furthermore, it is important to note that attacks are not necessarily confined to plants growing where the eggs of the cutworm moths were laid, because in severe outbreaks the cutworms' cultivated and weed host plants in the immediate vicinity of egg-laying may soon be completely defoliated or ringbarked, thus forcing migration to adjacent areas.

Life History and Habits.

The small, pearly-white, round eggs (Plate 11; fig. 1) are generally laid on moist soil under low-growing plants, such as pigweeds and bull-head, and at the end of an incubation period of about three days in

* *Euxoa radians* Gn.

DESCRIPTION OF PLATE 11.

BROWN CUTWORM.

Fig. 1.—Eggs × 20.
Fig. 2.—First-stage larva × 8.
Fig. 3.—Final-stage larva × 1½.
Fig. 4.—Pupa × 2.
Fig. 5.—Adult male, natural size.
Fig. 6.—Adult female, natural size.

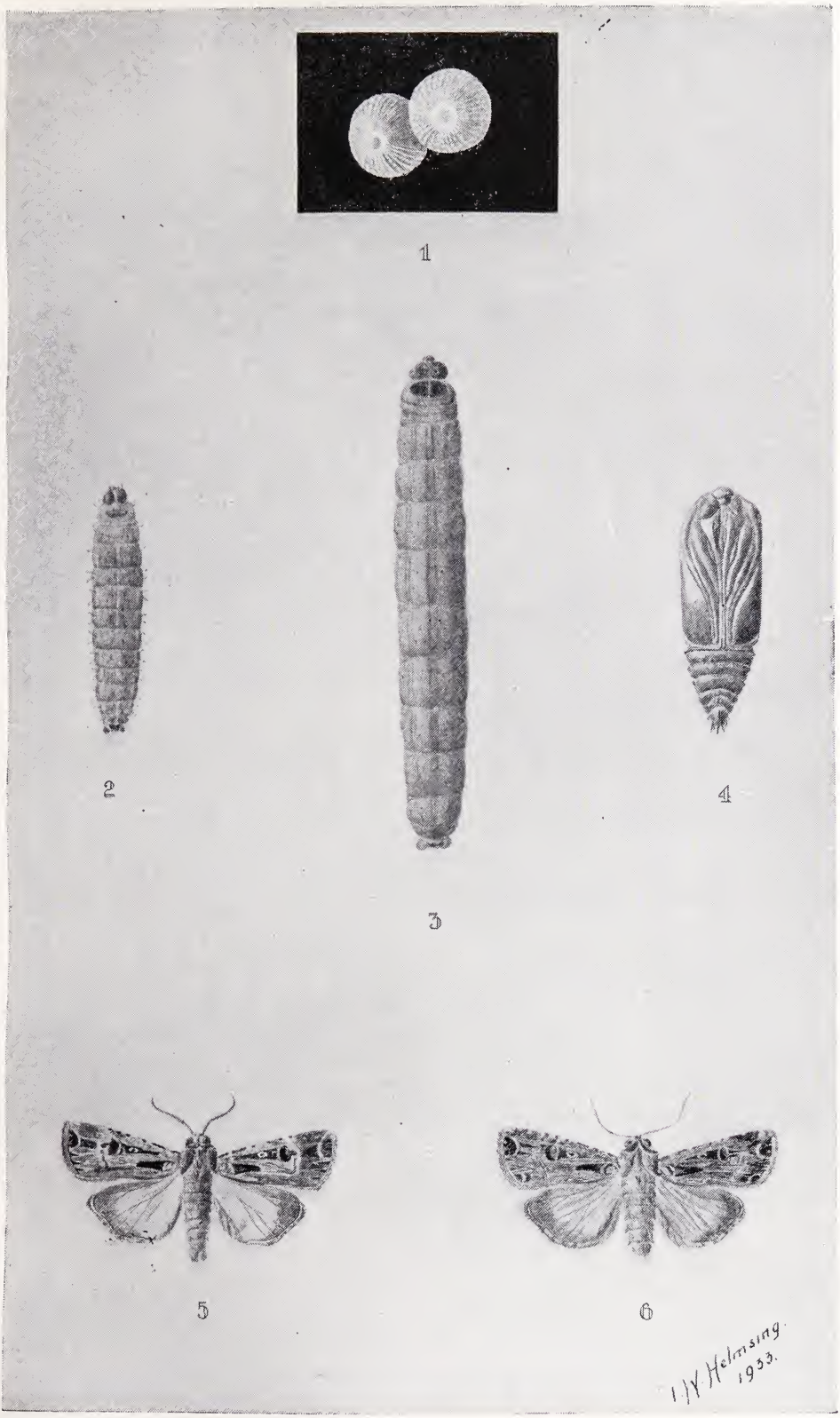

Plate 11.
BROWN CUTWORM.

Face page 54.

summer the young larvæ (Plate 11; fig. 2) or cutworms emerge to feed on the delicate foliage of these weeds or on accessible cultivated plants. They shelter in the soil during the day and come out to feed at night, eventually becoming full grown in about four weeks during the warmer months. The full-grown cutworms (Plate 11; fig. 3) are 1½ inches in length, and are grey-green or grey-brown, stout, soft-bodied larvæ possessing eight pairs of legs. At this stage the cutworms form earthen cells at shallow depths in the soil, and transform therein to shiny brown pupæ (Plate 11; fig. 4) from which the moths emerge a fortnight later. The moths (Plate 11; figs. 5 and 6) are unattractive, stout-bodied insects with a wingspread of 1½ inches, the predominant colour of the forewings being dark-brown, broken by conspicuous darker areas. The hindwings are greyish-white with brown margins, the body length being about two-thirds of an inch.

Control.

The control of this pest can, fortunately, be quite satisfactorily accomplished, the most obvious measure being the elimination of the weed plants under which the moth lays its eggs and on which the resultant cutworms may feed. Cultivation, at least a month before the area is planted, should therefore aim at the prevention of the growth of the pigweeds and bullhead, and once it is planted the ground should be kept as free as practicable of these weeds. If the weeds get out of hand in the planted area and are seen to be breeding large numbers of cutworms, the pigweeds and bullhead or other weed host plants should be destroyed by cultivation, but such destruction must be immediately followed by the application of the usual bran bait, for if this precaution is neglected, the cutworms will concentrate all their feeding activities on the cultivated plants, with very disastrous results thereto.

The preparation of this cutworm bran bait, which will be found very effective if properly prepared and applied, is fully discussed on page 3. One important point in its application is that it should be scattered in the late afternoon so as to be fresh and attractive when the cutworms emerge from the soil to feed about sunset. It is somewhat difficult to definitely state the amount of bait required per acre, this depending mainly on such factors as the intensity of the infestation, the nature of the attacked crop, and on whether the bait is to be broadcasted or applied in rows. The economics of the crop requiring protection will also frequently determine the amount of bait that can be profitably used. However, as a rough guide to the farmer, it may be stated that 50 lb. dry weight of bran per acre should prepare sufficient bait for a light broadcast, but when the bait is sprinkled in the rows of plants requiring protection half that quantity may suffice if the rows are 4½ feet apart. Much heavier applications may sometimes, however, be necessary on portions of the baited area where the infestation is abnormally high. There may thus be a very considerable variation in the rate of application, even in a single area.

This bait may be used as a precautionary measure following the destruction of cutworm-infested weeds in planted areas, or it may be employed where an attack on the cultivated plants is actually in progress throughout a cultivated area, the bait being scattered in small heaps close to but not touching the stems of the plants. In cases where cutworms are migrating from an uncultivated to a cultivated area or from one cultivated area to another, much good can be accomplished

by liberally scattering the bait in front of the line of advancing cutworms. Large numbers of the cutworms will feed on the bait and die without inflicting losses on the cultivated plants.

Ploughing a furrow a short distance in front of a line of migrating cutworms and scattering the bran bait in the bottom of such a furrow is another method of dealing with cutworm invasions. The steep side of the furrow should face the advancing cutworms, and to be successful the soil conditions must be suitable and the furrow well drawn. The side of the furrow next to the area requiring protection should be loose and crumbly, and if it becomes caked by rain it will no longer be effective, and must be redrawn if the cutworms are still on the move. This method of control is best carried out by opening the furrow and throwing the loose earth towards the area requiring protection. The return furrow is then cut into this, thereby leaving a line of loose soil above a steep face. It is frequently desirable to draw a second furrow to act as a barrier to the cutworms that succeed in passing the first furrow.

PLAGUE GRASSHOPPER.*

Many species of grasshoppers occur in Queensland, but for present purposes discussion will be confined to the insect commonly known as the plague grasshopper. This species not infrequently occurs in enormous numbers in different parts of the State, but several years generally elapse between widespread outbreaks, and these, fortunately, are not State-wide, although large areas, particularly in pastoral districts, may be involved. Grasshoppers may attack almost any cultivated plant, but the plague grasshopper is predominantly a pest of pastures and cereals, and will be discussed as such.

Life History and Habits.

The eggs (Plate 12; fig. 2) of the plague grasshopper are laid in long, narrow, somewhat curved, cylindrical cavities in the soil, these reaching a depth of 1½ to 2 inches (Plate 12; fig. 1). When about three dozen eggs have been laid, the cavity is sealed with a little cap which renders its exact position rather difficult of detection. Bare soil on a ridge or slight elevation seems to be favoured for egg-laying, and it is characteristic of these plagues that the egg-laying hoppers settle in enormous numbers on comparatively restricted areas; hence many millions of eggs may be laid on the one egg-bed site, which may vary in size from only a few square yards to several acres. Recently obtained evidence indicates that the adult grasshoppers may occasionally overwinter, but normally in Queensland, eggs are laid some time in May, and these eggs overwinter until the middle of September, when the first hoppers start to emerge. These young hoppers (Plate 12; fig. 4) spread very slowly from the egg-beds on which they hatched out, but as their development proceeds they move further afield and at a much more rapid rate. After a series of moults they become winged (Plate 12; figs. 6 and 7), development from hatching to the attainment of the winged stage occupying about six weeks in the case of this late spring and early summer generation. Three generations appear to occur under Queensland conditions, and as each female lays several batches of thirty or forty eggs it is not difficult to visualise the position at the end of summer if conditions have been favourable for the grasshoppers and no serious efforts have been made to control them. Thousands of acres of pasture

* *Chortoicetes terminifera* Walk.

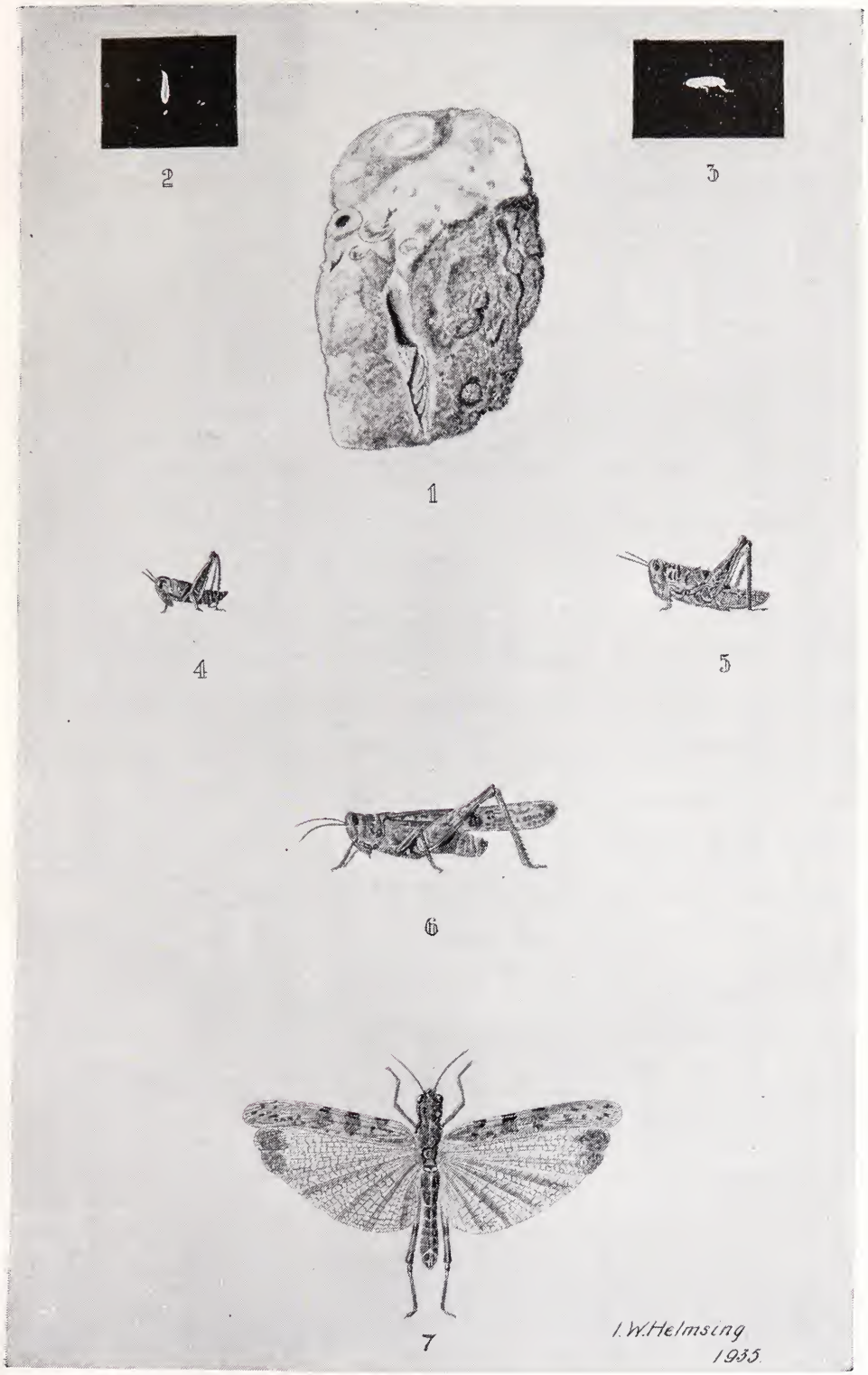

Plate 12.

PLAGUE GRASSHOPPER.

Fig. 1.—Soil showing egg tubes and eggs.
Fig. 2.—Egg.
Fig 3.—Newly emerged hopper.
Fig. 4.—Young hopper.
Fig. 5.—Pre-adult hopper
Fig. 6.—Adult.
Fig. 7.—Adult.
All figures natural size.

Face page 56.

and cereals may be more or less completely eaten out in a short space of time in an infested district. Not only is the pasturage destroyed, but recovery frequently seems to be decidedly slow, except when the attack is followed by good rains.

Control.

Queensland experiments have amply demonstrated the fact that a bran bait is very effective for killing the plague grasshopper, the mortality ranging from 80 to 90 per cent. The arsenical used in this grasshopper bait is not the Paris green generally employed in the preparation of bran bait for the control of cutworms, for in grasshopper control arsenic pentoxide is usually employed. The formula for the grasshopper bait and the manner of its preparation will be found discussed on page 3.

The bait prepared according to the directions given is broadcasted somewhat in the same manner as in the hand-sowing of wheat, and is uniformly applied in a very finely divided state wherever the young grasshoppers are present in appreciable numbers. Experience indicates that the amount of bait prepared according to the formula given on page 3 is sufficient for the treatment of about two-thirds of an acre of infested ground. The bait is best applied while the young hoppers are congregated together in large numbers; hence it is usually considered desirable to defer application of the bait until about a week after the hoppers have commenced to hatch. The hoppers of each generation may emerge over a period of several weeks, and as they do little damage and move but a short distance from the hatching-out ground during the first week, there is no necessity to take action on the appearance of the first hopper. The delay of a week will ensure that large numbers of young hoppers will be there to eat the bait as soon as it is applied.

It is usually necessary to bait a large egg-bed site a second time, and, indeed, even a third application may be necessary to deal with late-emerging hoppers. Experience shows that in the case of the spring generation the bait is best broadcasted between 9 a.m. and 2 p.m., so that it will be fresh when the grasshoppers are hungry and active. The feeding habits of the hoppers, however, differ somewhat in midsummer and during that season the bait should be applied between 8 a.m. and noon, or between 2 p.m. and 4 p.m. In this case a day-feeding insect is under consideration, whereas in the case of the brown cutworm, which has just been dealt with, control of a night-feeding insect is required; hence the difference in the time of application of the bait. Should the grasshoppers be advancing in swarms, as they habitually do in the later stages of their larval life, the bait should also be broadcasted over a strip 30 feet wide in front of the advancing swarms. When the grasshoppers in the swarms are still young and have not developed a rapid migratory habit, a baited strip 10 feet wide is, however, quite adequate.

Emphasis must be laid on the fact that success in dealing with grasshoppers depends on the application of the control measures during the first two or three weeks after the hatching of the hoppers. Although the older hoppers are killed by the bait, it must be remembered that they are scattered over a much greater area than in the earlier stages of their development; hence the cost of control is appreciably increased by delay, and, indeed, the swarms may be so scattered as to render control impossible. Control of the grasshoppers in the flying stage is definitely out of the question.

The control of this pest will be facilitated by carefully marking the sites on which flying swarms of grasshoppers settle for egg-laying. These should be kept under observation and should be baited at the time and in the manner indicated.

The danger to stock feeding over infested areas that have been properly baited is negligible. A guarantee of absolute safety, however, cannot be given; hence pastoralists and farmers are advised to exercise discretion in the application of the bait and to make sure that it is thinly and uniformly applied.

Should baiting material be not immediately available, some good can be accomplished by sprinkling old bags or similar material with kerosene and igniting the bags. The burning bags are then dragged over the swarms of hoppers, many of which will be killed. This method, however, should be regarded as a temporary expedient suitable for application only until such time as baiting material has been obtained.

CORN EAR WORM.*

One of the most destructive Queensland insects is the species now commonly known to cotton and other farmers as the corn ear worm. Among tobacco-growers this insect is generally referred to as the bud-worm, maize-growers know it as the maize grub, and tomato-growers call it the tomato worm.

The caterpillars on hatching from eggs laid on cotton obtain their first meal by feeding on the tender young leaves at the growing tip, in the stem of the growing tip or on the very young squares. As the attack progresses the squares are hollowed out (Plate 13; fig. 4) and are subsequently shed and destruction of the central shoot may follow feeding in the stem of the growing tip with the resultant production of an undesirable malformed type of plant. If the corn ear worm outbreak coincides with the commencement of squaring, the squares may be attacked and shed as quickly as they are formed, and in the event of favourable growing conditions the attacked plant's energies may be diverted, temporarily or permanently, to vegetative growth, boll production being negligible. Corn ear worm infestation, however, is only one of a number of factors responsible for excessive vegetative growth. The caterpillars also frequently attack bolls of all sizes (Plate 13; fig. 3), passing from one boll to another, the damaged locks in the boll becoming infected with moulds which may spread through the whole boll. Actually the loss of squares is usually more serious than the attack on the bolls for many of the latter may still yield quite marketable cotton from undamaged locks. The type of attack just described is that normally associated with corn ear worm bred on the cotton plant, but a migratory attack from other areas or host plants frequently occurs, and the plants may then be practically defoliated in the case of a young crop. In older crops, however, the corn ear worm still shows a marked preference for squares and bolls, even in the case of a migratory attack.

* *Heliothis obsoleta* Fabr.

DESCRIPTION OF PLATE 13.

CORN EAR WORM ATTACK.

Fig. 1.—Infested tomato.
Fig. 2.—Infested tomato.
Fig. 3.—Damaged cotton boll.
Fig. 4.—Damaged cotton square.
Fig. 5.—Damaged cotton boll.
Fig. 6.—Attack on growing tip of tobacco.
Fig. 7.—Attacked maize cob.
Fig. 8.—Attacked maize cob.

All figures half natural size.

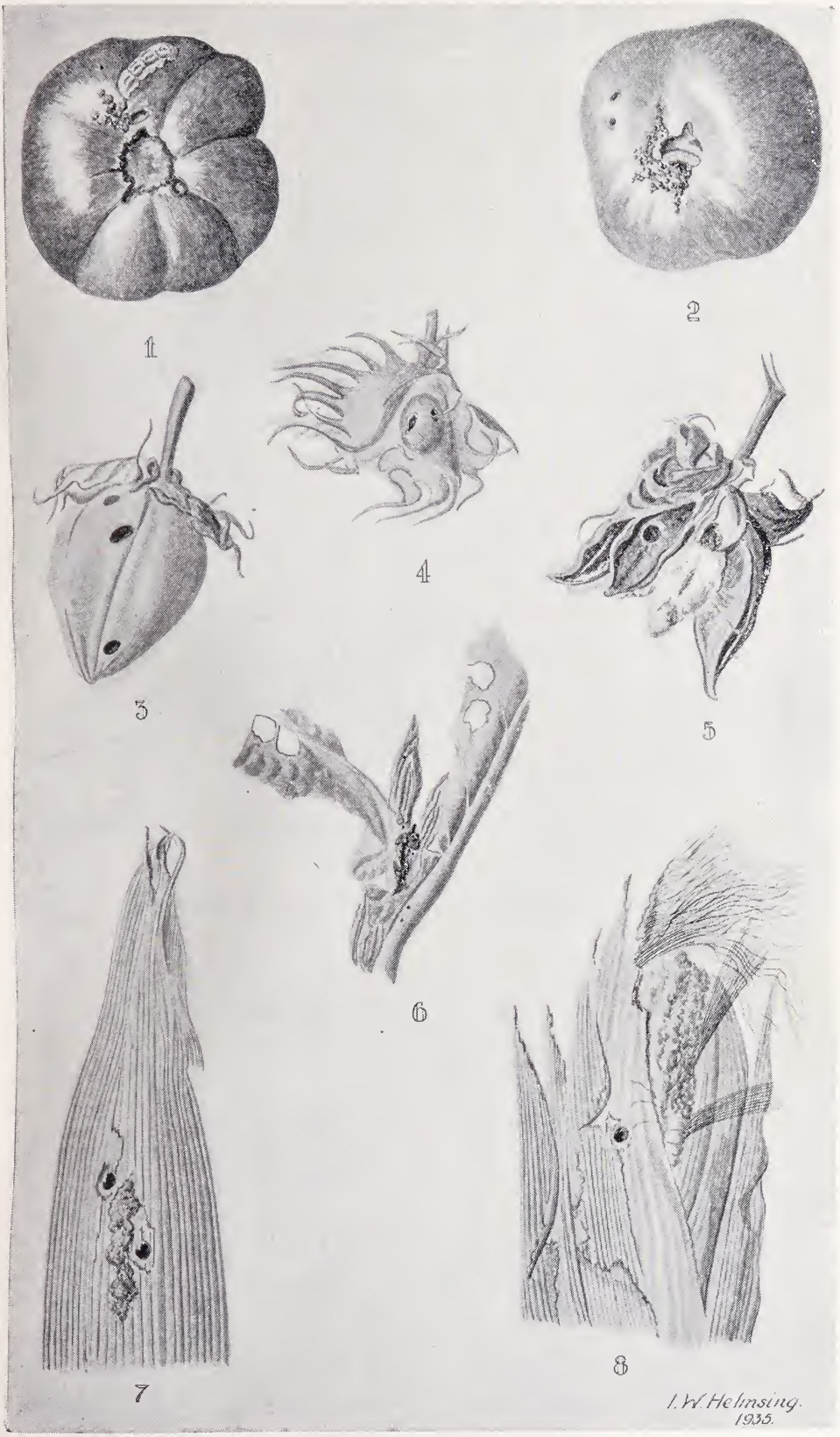

Plate 13.
CORN EAR WORM ATTACK.

Face page 58.

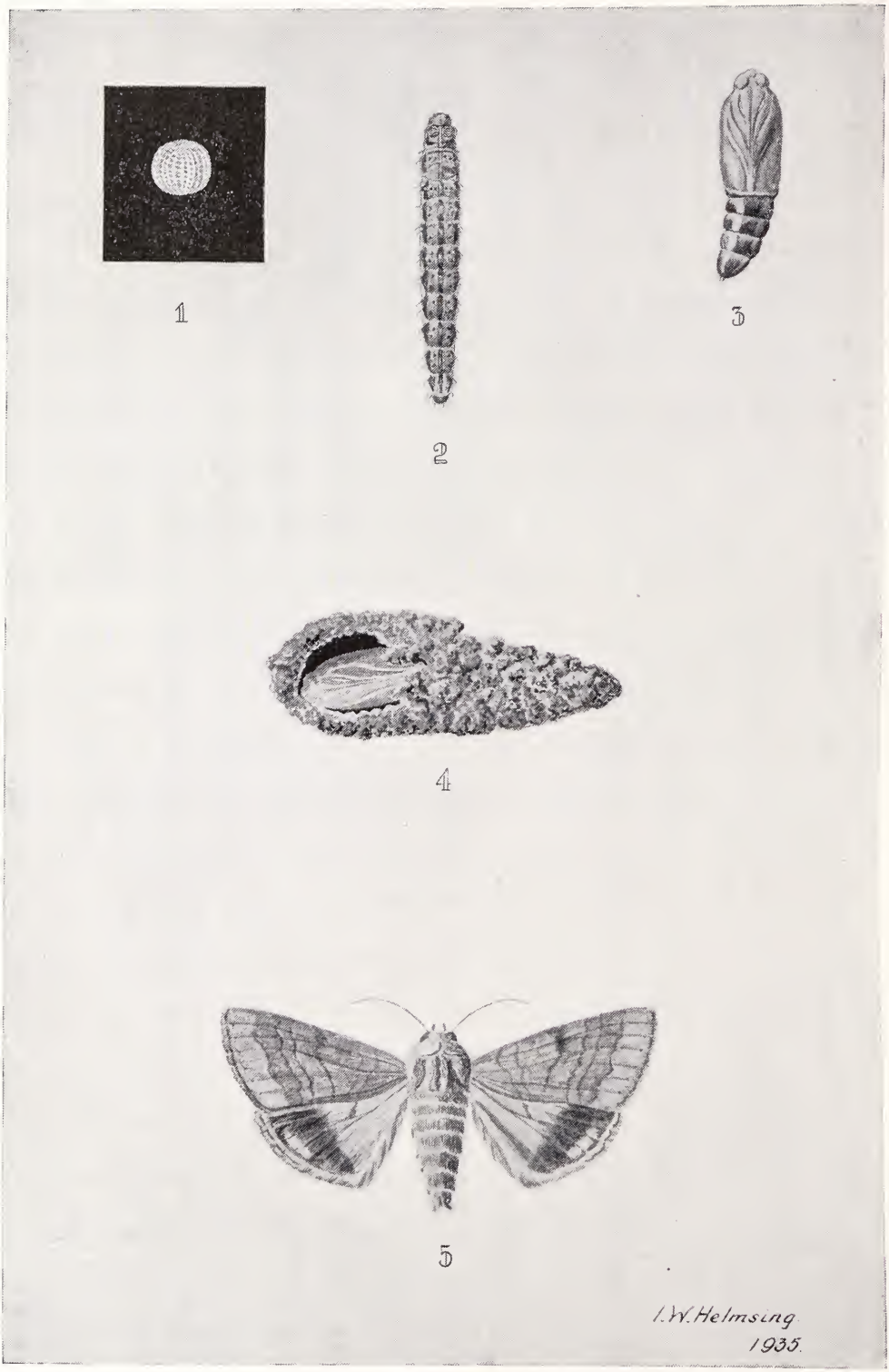

Plate 14.

CORN EAR WORM.

Fig. 1.—Egg × 14.
Fig. 2.—Larva, natural size.
Fig. 3.—Pupa × 1½.
Fig. 4.—Pupa in earthen cell × 1½.
Fig. 5.—Adult × 1½.

Face page 59.

This species is quite appropriately referred to as the budworm by tobacco-growers because it displays a very definite liking for the growing tip of the tobacco plant (Plate 13; fig. 6). It may bore down the stem and the terminal bud may be destroyed, thus leading to the production of lateral buds, which may also be the subject of attack. Most of the larvæ, however, feed exposed on the leaves, which may be either wholly or partly destroyed. When attacking maize, the corn ear worm feeds on the silk, tassels, cob (Plate 13; fig. 8), and leaves. Blossom loss in tomatoes is often due to its activities, and the fruit thereof is also an object of attack, entry thereto being generally obtained at the stem end (Plate 13; fig. 1). Here, again, the caterpillar shows a marked tendency to move from fruit to fruit, numbers thereof being rendered valueless by a single individual. Lucerne and cabbages may also be seriously attacked.

Life History and Habits.

The pearly-white, dome-shaped eggs (Plate 14; fig. 1) are about half the size of a pinhead, and are generally laid singly on the flowers, flower buds, or young foliage, the moth normally laying about 1,000 eggs during the two weeks of its life. After an incubation period of three to six days whitish larvæ emerge from the eggs, and in a short time acquire quite a pronounced colour pattern. The colour varies very considerably in the full-grown corn ear worms (Plate 14; fig. 2), some specimens being dark-brown, while others are a pale-green, the general colour being varied by a number of stripes of different shades. The caterpillars, which possess eight pairs of legs, are about 1½ inches in length when full growth is attained at the end of two or three weeks. Pupation then takes place in an earthen cell (Plate 14; fig. 4) in the soil at a depth of 3 or 4 inches, the brown pupæ (Plate 14; fig. 3) measuring about three-quarteers of an inch in length. During the warmer weather the pupal stage normally lasts ten to fourteen days, at the end of which period the stout-bodied moths emerge (Plate 14; fig. 5). The wing expense of the moths is about 1½ inches, the forewings being reddish-pink and the hindwings creamy-yellow with large marginal smoky areas.

Control in Cotton.

Experience in Queensland has not yet definitely demonstrated that the corn ear worm in cotton can be successfully and economically controlled by the use of insecticidal dusts. Further experiments on dusting with arsenicals are at present under way, but in the meantime growers must look to cultural practices as the best line of attack, and, fortunately, there is justification for the belief that strict attention thereto will greatly minimise corn ear worm losses, at least in so far as the Callide and Dawson Valleys are concerned. In these valleys, but more particularly in the former, agriculture is practically confined to the growing of cotton, and the problem is thus a fairly straightforward one. Elsewhere it is not so simple, because other economic host plants of the corn ear worm such as maize, tobacco, tomato, and lucerne may be extensively grown, thereby constituting a serious complicating factor.

The first point to be noted is the fact that cotton is not an important host plant of the corn ear worm until it is squaring freely, which should be in December if early planting has taken place in a normally favourable season. From the middle of December, however, the cotton plant may suffer severe injury, the squares being attacked and shed almost as fast as they are formed. The next important point is that

the overwintering pupæ of the corn ear worm give rise to moths in September, which means that at least two generations are bred before cotton comes appreciably into the picture, and the caterpillars of those generations must feed on other host plants, the most important weed hosts being the pigweeds, twin leaf, and wild cape gooseberry, bullhead and a few allied weeds being also attacked in a lesser degree. Spring crops of maize and tomato may also constitute a menace which will subsequently lead to serious infestation of the much more important cotton crop—*i.e.*, in so far as the Callide and the Dawson are concerned.

The potentially enormous body of favoured weed host plants in the spring and early summer, however, very definitely constitutes the chief menace, and every reasonable endeavour should, therefore, be made to keep them well in check both within the cultivated cotton areas and in the vicinity thereof. The areas to be planted should receive thorough preparation to eliminate weeds, and the battle against the weeds in the young crop must be continued as long as practicable. Old cultivation paddocks such as maizefields and wheatfields require attention. The former must, if possible, be ploughed before spring to destroy overwintering pupæ, and the latter should be ploughed early, both being planted to a suitable crop or grass cover. They should on no account be left in a neglected condition, for pigweeds and bullhead will flourish in such areas and produce an enormous corn ear worm population in the early summer months, thus leading to severe losses in the cotton from mid-December onwards. If standover cotton is ratooned the weed host plants in it must be cleaned up, but if it is not to be ratooned it should be eliminated as soon as possible. From what has just been said it is evident that success in dealing with corn ear worm in cotton in the Callide and Dawson Valleys is definitely linked up with the elimination of the weeds on which it breeds so freely in the spring and early summer, and the cotton-grower must accordingly wage an incessant warfare thereon.

Similar attention to weed elimination in other cotton districts will also be productive of beneficial results, but, as already indicated, in districts other than the Callide and Dawson alternative host plants such as tomato, lucerne, maize, and tobacco may breed large numbers of the corn ear worm and thus provide a source from which the cotton may be infested. Even so, weed elimination is still worth while, for at the worst it is sound agriculture, apart altogether from any beneficial results it may produce in the campaign against the corn ear worm. It is obvious that cotton should be sown at as great a distance as practicable from lucerne and other alternative cultivated or weed host plants so as to minimise the risk of infestation therefrom.

A further most important step in minimising corn ear worm attack is the preparation of the land for planting with the first suitable rains after the end of the cold weather. Given good cultural attention, crops planted then have a reasonable prospect of success. Early planting usually ensures that a good bottom crop is set, and that the plants have hardened up before the peak of the corn ear worm infestation. It is equally important, however, that such early planting be combined with the use of new land or of old land broken up after a few years under Rhodes grass. Such a combination assists materially in producing a reasonable crop of cotton even in seasons when corn ear worm is prevalent.

Maize trap crops have been recommended for the control of this pest, but they are a menace rather than a protection against infestation unless very carefully handled. Recent experiments, however, indicate that trap crops of successive maize plantings swabbed with the mixture discussed on page 74 may be of value in corn ear worm control; further experiments are, of course, necessary before a definite recommendation is possible. The discussion on page 74 also indicates that migrations of corn ear worm to cotton fields from outside sources can be dealt with by certain measures recommended for the control of the cotton web-spinner.

This discussion on maize trap crops is an appropriate point at which to give consideration to the safest method of producing maize on a cotton farm, either for sale or for consumption on the farm as stock feed. In such cases, it is desirable that the maize be obtained from a succession of plantings rather than from a single sowing, but under no circumstances whatsoever, at least in so far as the control of corn ear worm is concerned, should maize be sown earlier than late November, otherwise serious corn ear worm infestation of cotton is almost inevitable. If a single sowing is made it will breed up a large corn ear worm population to spill over into the cotton when the maize is harvested or fails to mature a crop, whereas if a succession of smaller plantings is made, the corn ear worm population will move from the older maize to the younger maize instead of to the cotton. Volunteer maize in cotton fields should be promptly destroyed.

Control in Tobacco.

Insecticidal control of the corn ear worm in tobacco and of certain other tobacco pests is quite a practicable proposition and is generally adopted in Queensland plantations. Where severe infestation is likely the best procedure is to apply an arsenate of lead dust to the plants in the field twice weekly after transplanting, the dusting ceasing when the plants are about 9 inches in height. This dusting assists in the control of leaf miner, stem borer, cluster caterpillar, and green tobacco loopers, and is also of value in dealing with the corn ear worm. Because of the possibility of arsenical contamination of harvested leaf, however, it is considered desirable to cease dusting when the plants are 9 inches high, a dry bait then being substituted for the dust for the control of the corn ear worm. One pound of arsenate of lead is thoroughly mixed with 25 lb. of pollard, or with a similar quantity of maize meal if it is available. This dry bait is applied at frequent intervals to the growing tips of the tobacco plants by means of a finely perforated tin can, and is attractive to the corn ear worm, and also to the cluster caterpillar, which is another species frequently found feeding in characteristic clusters on tobacco leaves. Insecticidal treatment in the tobacco seedbeds is discussed in some detail on page 65.

Control in Tomatoes.

When attempting to control corn ear worm in tomato crops the reader should keep clearly in mind what has been said about the control of this pest in cotton. Weeds on which it can breed should accordingly be eliminated and any useless neglected economic host plants should be similarly dealt with. Infested tomatoes can be destroyed by boiling, or by any other appropriate method which will kill the larvæ. Many pupæ of this pest will be destroyed if infested ground is thoroughly cultivated prior to planting, such cultivation also destroying weeds on

which the corn ear worm or tomato worm may be breeding. Many growers spray or dust their crops with arsenate of lead, the tomatoes being cleaned before marketing. Such a procedure accounts for considerable numbers of the tomato worm, but, unfortunately, it may be responsible for undesirable quantities of injurious spray residues on the tomatoes when marketed; hence it seems desirable to dispense with the application of arsenical dusts and sprays to tomato plants carrying fruit. A suitable non-arsenical insecticide may be evolved, but that is a matter for future experimentation.

Control in Maize.

Insecticidal treatment of growing maize is both impracticable and financially unsound, hence protection against corn ear worm attack on this crop can be attempted only along the general cultural lines discussed when considering its occurrence in cotton and tomatoes.

Control in Lucerne.

The position with respect to infestation in lucerne is similar to that outlined in the case of maize, insecticidal control being out of the question partly because of cost and partly because of poisoning risks. Premature harvesting of a heavily infested crop will appreciably increase the corn ear worm mortality and the succeeding crop may consequently be much less heavily infested.

TOBACCO CLUSTER CATERPILLAR.*

The larvæ of a moth closely allied to the corn ear worm or budworm moth are very frequently associated with tobacco, often constituting a menace quite comparable to that of the budworm. The moths lay their eggs in large batches, as many as 300 being deposited by a moth in one group; the masses of eggs are covered with light-brown hairs from the bodies of the moths. The caterpillars characteristically feed in groups during the earlier stages of their larval life and eat the leaf tissue between the veins, the latter, however, being left intact. The older larvæ lose the gregarious habit and wander all over the plant when feeding. When full grown the larvæ are dirty-brown in colour and possess a number of conspicuous black triangular marks on each side of the body, which is about $1\frac{3}{4}$ inches in length. Pupation takes place in an earthen cell in the soil and the stout-bodied moths emerge after the usual incubation period. Various shades of brown and grey constitute the colour pattern of the forewings, the hindwings being iridescent-grey with a dark, narrow hind margin. The moths have a wingspread of $1\frac{1}{2}$ to $1\frac{3}{4}$ inches.

Control.

Dusting the plants in the field with an efficient arsenate of lead dust until they reach a height of 9 inches, as recommended for the control of the corn ear worm in tobacco will greatly reduce cluster caterpillar infestation. After that stage in the growth of the plants has been reached the dry bait employed against the corn ear worm in tobacco must be used and will be found somewhat effective against the cluster caterpillar, its efficiency increasing with an increase in the age of the caterpillars to be controlled.

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* *Prodenia litura* Fabr.

GREEN TOBACCO LOOPERS.*

Two other species belonging to the same family as the budworm and the cluster caterpillar moths lay their eggs on tobacco, and from these eggs emerge green caterpillars which move with a peculiar looping motion, this motion serving to distinguish them from other caterpillars commonly found on tobacco. They usually feed on the under surface of the leaf, and when full grown at the end of two or three weeks' larval life they measure from 1 to 1½ inches in length. They then pupate in silken cocoons attached to the under surface of the leaf near the midrib. The wings of the moths emerging from these pupæ are golden-brown in colour, and each of the forewings bears conspicuous silver spots, the wingspread varying from 1¼ to 1½ inches. On some plantations these loopers are actually more destructive than the budworm, and on many other plantations they cause quite an appreciable commercial loss.

Control.

The loopers will feed on the dry bait used for budworm or corn ear worm control if they encounter the bait while wandering over the tobacco plant. They do not, however, appear to be attracted to it as is the case with the budworm and the cluster caterpillar; hence the somewhat unsatisfactory procedure of hand picking the loopers may have to be resorted to in the later stages of the growth of the crop. The dusting of the plants in the field until they reach a height of 9 inches, as discussed in the consideration of corn ear worm control will, of course, check the looper infestation in the early stages of the growth of the tobacco crop.

TOBACCO LEAF MINER.†

The tobacco leaf miner is the small insect generally referred to by potato growers as the potato tuber moth, an adequate description of the life cycle stages of which will be found on page 85. No additional discussion of these stages is necessary for present purposes, hence the following paragraphs are confined to a consideration of the insect's association with tobacco and its control thereon, it having been deemed undesirable to discuss the tobacco infestation in the paragraphs devoted to the potato tuber attack.

Life History and Habits.

The larvæ (Plate 20; fig. 3) attack the plants in both the seed-bed and the field and tunnel extensively in the leaves (Plate 15), forming irregular patches or blotches in which the central tissue is eaten out, leaving only the thin upper and lower surfaces intact. These mines occur on any part of the leaf and are irregular in outline, but are generally adjacent to the midrib or a main vein. Infestation may extend to the stems of older plants in cases where the outbreak is severe, but tunnelling in the stems is confined to the tissue immediately underlying the surface, whereas in the case of the closely allied stem borer, tunnelling occurs in the pith. Infestation in seed-beds may lead to serious loss of seedlings before transplanting, while in the field many transplants may succumb before re-establishing themselves, several instances having occurred in which as many as six transplantings failed to produce a reasonable stand. Attacks should not normally kill the older plants,

* *Phytometra argentifera* Gn. and *Phytometra chalcites* Esper.

† *Phthorimæa operculella* Zell.

Plate 15.

INSECT-ATTACKED TOBACCO LEAVES.—*Upper fig.*, showing extensive damage by the tobacco leaf miner. *Middle fig.*, a further example of damage by the tobacco leaf miner. *Lower fig.*, showing leaf mining activities of the tobacco stem borer.

but the grade of the infested leaf produced thereon is at least appreciably reduced, and a considerable proportion of the mature leaf may be so badly infested as to warrant its rejection for curing.

Control.

Control may be attempted along several lines, attention being first directed to the prevention of infestation in the seed-beds. In connection therewith a satisfactory practice is to dust the seedlings with an arsenate of lead dust twice weekly, this application being mainly for the control of leaf-eating insects such as the budworm, the green loopers, and the cluster caterpillar. From what has been said in discussing the life history of the leaf miner it is obvious, however, that dusting with arsenate of lead cannot be relied upon to kill a very large percentage of the larvæ before they enter the leaf tissue to mine therein unless the plants are dusted at least thrice weekly; nevertheless fewer dustings are productive of some beneficial results even in the case of the leaf miner.

A recent comprehensive experiment with the colloidal copper spray employed for the control of blue mould has opened up further distinctly interesting possibilities with respect to leaf miner, for it gave a very satisfactory degree of control of that pest. This and other evidence indicates that if that spray be employed for the control of blue mould in a regular and efficient manner it will also produce a material reduction in the leaf miner population. The procedure adopted in the experiment was as follows:—the colloidal copper spray was applied late in the afternoon after watering the seed-beds, which were again heavily watered early the following morning, the seedlings being then dusted with a 50 per cent. arsenate of lead dust between 7 a.m. and 8 a.m. Further watering that day was unnecessary except when the seed-beds were abnormally dry. This procedure was repeated twice weekly and, in so far as the control of leaf miner was concerned, gave much better results than arsenical dusting alone.

Another, and in many ways the most satisfactory, method of dealing with possible leaf miner attack in the seed-beds is by the exclusion of the moths, thus preventing the laying of the eggs therein. The moths are not on the wing between the hours of 10 a.m. and 5 p.m. and the seed-beds can then be safely exposed. At all other hours, however, they may be protected by moth-proof covers of a material such as Rhodesian cloth, the ends of the beds being securely closed. This material is sufficiently transparent to permit the passage of adequate light and stunting of seedlings, due to excessive shading in the early morning, is thus unlikely. Hessian covers for protection against storm rains may be necessary in some districts in addition to the lighter material. The special calico or duck covers used in benzol vapour treatment for blue mould control must be removed earlier than 10 a.m. to obtain the benefits of the early morning sun. These covers automatically exclude leaf miner and stem borer moths for at least most of the time they are on the wing and thus give partial, though not complete, protection.

Only healthy uninfested seedlings should be planted in the field, but the fight against the leaf miner does not cease then, for the seedlings are still exposed to infestation which may be particularly serious in its results if the transplants are checked in their growth by adverse climatic or other conditions. Hence if it is in his power to do so, the grower should hasten the transplants over the critical period immediately following their removal from the seed-bed to the field. Furthermore,

frequent light applications of an arsenate of lead dust, preferably thrice weekly, are desirable until the plants attain a height of about 9 inches, dusting then ceasing in order to ensure that undesirable quantities of arsenical residues are not present on the marketed leaf.

The next point for consideration is the elimination of breeding grounds during the months intervening between successive crops of tobacco, and in this direction much can be accomplished, because in some of the more important tobacco districts practically nothing but tobacco is grown; hence, if tobacco plants are uprooted and destroyed by fire as soon as possible after the completion of the harvesting of the leaf and if volunteer plants are similarly dealt with, the new tobacco crop should get a good start free from any serious infestation. The position will be still further improved if the destruction of these tobacco plants is accompanied by the elimination of several leaf miner weed host plants, which occur in the main tobacco districts and are botanically closely allied to tobacco. Furthermore, where tobacco is the main consideration the growing of other crops such as potatoes, which breed enormous numbers of this pest, is distinctly inadvisable because such crops help to bridge the gap between the tobacco crops and thus assist in providing an unbroken succession of host plants in which the leaf miner can continue breeding. Again, from the point of view of insect control, the production of two tobacco crops in twelve months, which has been attempted in some districts, is undesirable and should be avoided.

TOBACCO STEM BORER.*

The stem borer is one of the most destructive insects associated with tobacco, its ravages being particularly serious in North Queensland. Its larvæ feed in both leaf and stem, but the chief loss arises from their presence in the latter. Stem borer infestation occurs in the seed-bed and in the field, the degree of loss being in some measure dependent on the prevailing weather conditions. When these are favourable to the rapid development of the crop, losses may not be severe, but should any other unfavourable factor be superimposed on the stem borer infestation many of the attacked plants in the field may be killed, death resulting partly from the insect attack and partly from the fungal infection for which it paves the way.

Life History and Habits.

The moth is about the same size as the leaf miner moth, but its forewings are brick-brown in colour, whereas in the leaf miner they are greyish with a few blackish streaks and dots. After hatching from the eggs, the small larvæ of the stem borer generally enter the leaf in the vicinity of a vein and reach the latter through a short linear mine. They then bore down the vein to the midrib of the leaf and eventually reach the stem of the plant where they feed in the pith (Plate 16; fig. 2). Occasionally in working down the midrib to the stem they excavate a few short tunnels which run into the leaf tissue (Plate 15), but they usually tunnel to the stem as directly as possible. Development may sometimes be completed in the midrib. The larvæ of this species cannot be distinguished by any structural characters from those of the tobacco leaf miner, but the marked differences in the selection of feeding grounds in the plant adequately serves to separate the two species. Larval development is completed in three to six weeks, and the larvæ then move to the tissue immediately underlying the

* *Phthorimæa heliopa* Low.

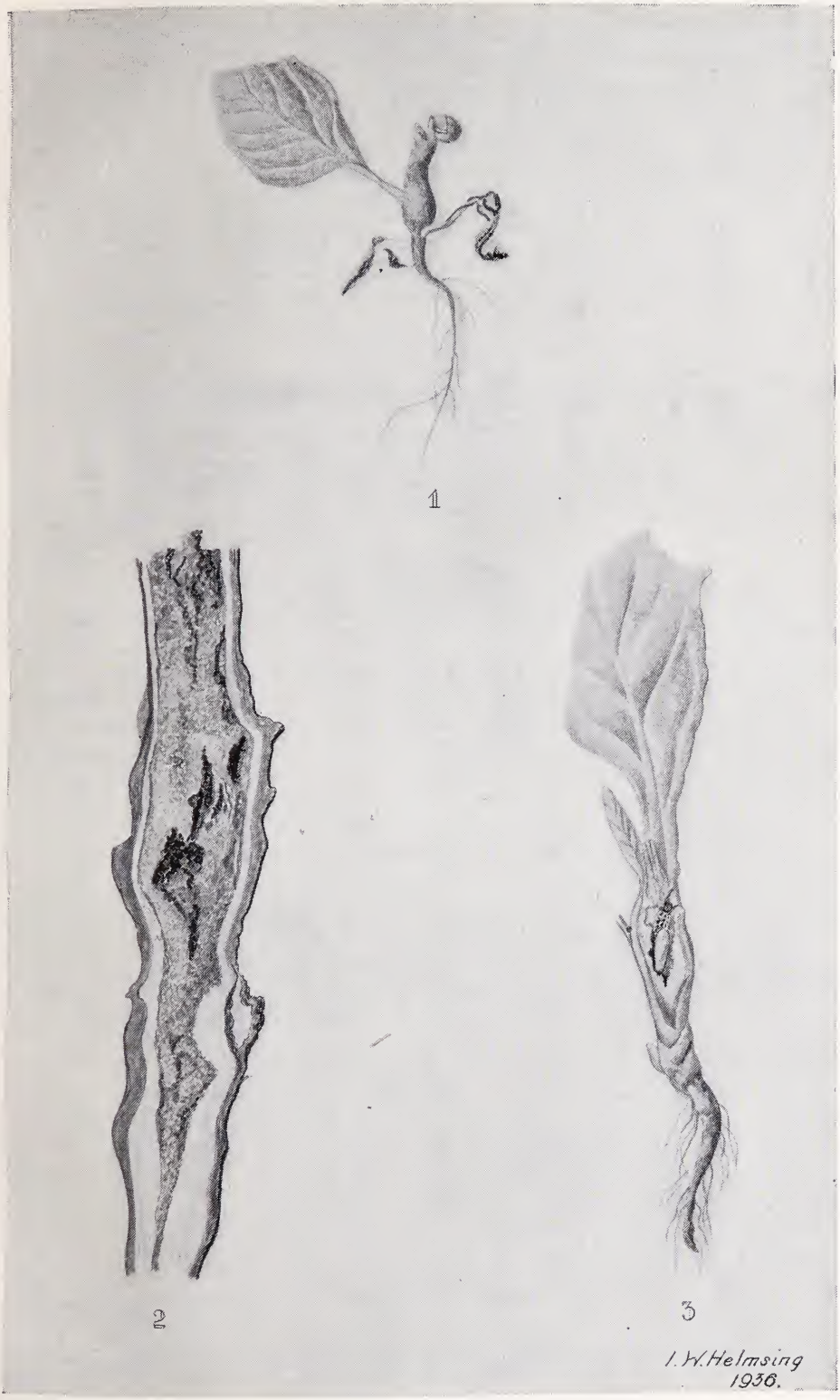

Plate 16.

Tobacco Stem Borer Attack.—Fig. 1.—Seedling showing gall development. Fig. 2.—Mature stem tunnelled by stem borer. Fig. 3.—Plant showing pupa *in situ*. Cavity of gall exposed.

Face page 66.

outside of the stem and pupate in pupal chambers separated from the outside by a very thin layer of tissue which is easily ruptured by the emerging moths after the completion of the usual pupal period. There is a considerable degree of difference between the results of infestation in the seed-bed and in the field. In the former case the tips of the young plants are malformed and a gall formation is produced as a result of the swelling of the stems within which the larvæ are feeding (Plate 16; fig. 1). Once plants have become established in the field, however, this gall formation is less characteristic, but stunted growth may continue to be a feature, this being accompanied by extensive suckering.

Control.

The control of this species may be achieved along lines similar to those discussed in connection with the tobacco leaf miner. An additional control measure which may be adopted in the field if growing conditions are favourable is the cutting back of infested tips to the axils of the lower leaves, the infested tips being destroyed. This procedure may frequently result in the production of marketable leaf from infested plants.

TOBACCO SEED HARVESTING ANTS.*

A number of species of ants collect tobacco seed from the seed-beds before it has germinated and transport it to the underground galleries in their nests, where it is stored to meet the future food requirements of the ant community. A few species occasionally cut off and harvest the very small leaves produced at germination, these species also possessing seed-harvesting habits. In districts where these ants are abundant, the outcome of such activities is frequently reflected in an extremely poor stand of seedlings even when all conditions, other than the presence of the ants, justified the grower's expectation of a splendid stand. In some cases the seeds are carried right away from the seed-beds, but in others a good proportion are piled up near the openings of nests in the beds, and in the latter eventuality the seedlings that do germinate are weakly valueless specimens. Losses from the peculiar feeding habits of these ants are commonest in North Queensland, and their prevalence may result in growers experiencing great difficulty in producing sufficient seedlings to plant up the area prepared for tobacco.

Control.

The first step in dealing with tobacco seed-harvesting ants is the selection of a seed-bed site as free as possible and as remote as possible from ants' nests. Two of the larger species of seed-harvesting ants generally form their nests at considerable distances from each other, and sites can usually be selected on which these two species will give no trouble. The funnel ant† is another species that may usually be avoided, and it is well worth while endeavouring to do so, because the mounds of earth thrown up in seed-beds by this species can do a great deal of harm to the seedlings. If it is not practicable to choose a site free from these funnel ants, the nests, which are quite easily located, should be destroyed by fumigation somewhat in the manner described on page 108.

* The species of seed harvesting ants belong to the genera *Meranoplus, Monomorium, Pheidolacanthinus,* and *Pheidole.*

† *Aphœnogaster ruginota* For.

Even when the above precautions have been taken, consideration has usually to be given to the smaller species of seed-harvesting ants, the nests of which occur in closer proximity to each other. Indeed in many districts in North Queensland it is practically impossible to select seed-bed sites free from these insects. Fortunately, very slight alterations in seed-bed practices enable the grower to deal effectively with them. All that is required is a top-dressing about one-eighth of an inch deep of medium-grade river sand the top-dressing being applied after the seed has been sown. This practice is now generally adopted in certain districts in North Queensland, and experience indicates that about one and a-half kerosene tinsful of sand are required to top-dress each 100 square feet of seed-bed. This covering does not interfere with the germination of the seedlings and affords adequate protection from the ants. In order to minimise the chances of introducing weed seeds to the seed-beds it is desirable to use well-washed river sand obtained from portions of the river bed subject to constant or frequent submersion. Where river sand is unprocurable, light sandy soil may be used, but it should be sterilized by burning before being applied as a top-dressing, and should be free from any tendency to cake.

The control measures outlined above will dispose of the seed-harvesting ants, but attention has still to be given to the leaf-cutting species which attack the very small leaves of the seedlings. Here again the position is now quite satisfactory, for these species, which are rather limited in their incidence as pests, can be effectively controlled by the application of a bait should a grower be unfortunate enough to encounter them in his seed-beds despite the precautions observed in selecting a site. This dry bait is simply maize meal which is broadcast on and in the vicinity of the infested seed-beds at the rate of 12 ounces of the meal to 100 square feet of seed-bed. The broadcasting may have to be repeated at three or four-day intervals during the weeks succeeding germination, but usually only one or two applications are required. It was previously considered essential to incorporate Paris green in the bait in the proportion of one part of Paris green to fifty of the maize meal, but the presence of the poison has now been demonstrated to be unnecessary, all that is required being to offer the ants readily transportable and attractive food that will serve to divert their attention from the seedling leaves.

TOBACCO THRIPS.*

Extensive silvering of maturing leaves sometimes occurs on tobacco in the Texas and adjoining districts, the percentage of mature leaf attacked being occasionally as high as seventy-five. This type of injury is caused by a species of thrips feeding on the leaf surface in the vicinity of the midrib and the main veins, usually on the upper surface, where it produces a silvered or frosted appearance. Heavily attacked leaves are reported to be unsatisfactory in quality when cured, their colour being dingy-brown.

Life History and Habits.

The full grown thrips responsible for this damage is a slender greyish-brown insect one-sixteenth of an inch in length, its immature stages being creamy-white. Little is known of the seasonal life history of this species in Queensland.

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* *Hemianaphothrips concinnus* Morrison.

Control.

Nicotine sulphate or derris sprays or dusts, applied so as to cover both surfaces of the leaves of infested plants, should produce considerable mortality in the tobacco thrips. More than one application, however, is required to give reasonable control, and difficulty may be experienced in treating a considerable area of well advanced plants. Tobacco-growers may prefer to use a home-made tobacco extract on account of the cost factor, but they are reminded that a guarantee of the effectiveness of these extracts is not possible. When harvesting, it is desirable to separate the damaged from the unblemished leaf so that the latter may receive first consideration in curing. Furthermore the prompt destruction of tobacco plants on the completion of harvesting, a procedure which is necessary for the effective control of other tobacco pests and diseases, will materially assist in reducing the tobacco thrips population.

TOBACCO BEETLE.*

Tobacco leaf stored in bulk sheds on the farms awaiting sale to the manufacturers may become severely infested by a small beetle appropriately known as the tobacco beetle, because of its partiality for tobacco leaf, cigarettes, and cigars. This light-brown rounded beetle ranges in length from one-sixteenth to one-tenth of an inch, its size being dependent on the nature of the supply of food available during the larval stage. The very minute eggs are laid singly in bulked tobacco leaf and the white, curved, hairy larvæ, which possess light-brown heads, hatch out after an incubation period of one week. These larvæ are full grown four to ten weeks later, and then measure one-twelfth of an inch in length. They generally pupate in the vicinity of the midribs or along the folds of the tobacco leaf, the walls of the pupal cells being composed largely of the leaf debris, and a week later the beetles emerge from the pupæ. The beetles do not cause much loss, but their larvæ feed very voraciously, and as a generation can be completed in six weeks infestation may rapidly become serious, particularly in view of the fact that the egg-laying capacity of the beetle may be as high as 100.

Control.

Most of the tobacco beetle trouble in bulk sheds in Queensland has its origin in carry-over leaf which has not been sold at the end of the season in which it was grown and cured. This leaf is usually green tobacco which it is hoped will change to mahogany with further storage in bulk and thus become saleable. Unfortunately, the tobacco beetle frequently gains access to such tobacco and may work great havoc therein. Furthermore, it will transfer its attention to the bulks of the more valuable leaf of the new season's crop and much damage may be inflicted before the grower realises that anything is amiss.

Clearly it is essential that the new season's tobacco leaf be stored in a bulk shed that is free from infestation; hence infested carry-over leaf should be removed from the bulk shed and, if necessary, the building should be fumigated with carbon bisulphide in order to kill any remaining tobacco beetles. The new leaf can then be bulked in the shed with reasonable safety and little or no infestation should normally take place in the comparatively short time usually elapsing between bulking and the sale of the leaf.

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* *Lasioderma serricorne* Fabr.

The carry-over or other tobacco leaf that is infested may be freed from infestation by heat treatment, experiments having demonstrated that all stages of the tobacco beetle are killed if the leaf be exposed to a temperature of 140° to 150° F. for a period of two hours. This can readily be accomplished by using an ordinary flue-curing barn, but it is essential that the bulks be completely broken down and the hands of tobacco strung out as in the original curing, otherwise the requisite degree of heat penetration will not be obtained. The tobacco leaf, after heat treatment, can then be stored in a clean bulk shed, but if it has to be returned to the shed in which it was previously stored that shed should be freed from infestation by carbon bisulphide fumigation prior to once more receiving the heat-treated tobacco. Growers are reminded that success in fumigation is largely dependent on making the bulk shed reasonably airtight, hence all crevices should be securely sealed with bagging or other suitable material or pasted over with stiff brown paper before liberating the carbon bisulphide in the building.

PINK BOLL WORM.*

The pink boll worm of Queensland is potentially one of the most serious pests with which the cotton grower may have to contend, but, fortunately, during the last few years it has been of slight importance. This happy position has been attained and maintained only as a result of strict attention to certain precautionary measures, the abandonment of which would soon lead to the development of a very serious position. As its common name indicates, this pest shows a marked preference for feeding in bolls which may be attacked at all stages of growth, but usually infestation does not take place until the bolls are at least half grown. Attack in the early stages of development generally causes their shedding, but that is not the case in the older bolls. The larvæ eat into the green bolls and, at first, attack the lint, which is cut and stained, but as the bolls become more mature attention is devoted almost entirely to the seeds with a consequent serious check to the development of the lint which is of an inferior quality, the attack, of course, destroying the seeds for planting purposes, and also largely if not entirely eliminating their value for oil extraction. Flowers, squares, and terminal shoots may be attacked by this species, but the boll infestation is the phase of attack that is of economic importance.

Life History and Habits.

The extremely small somewhat iridescent eggs are white when laid but they develop a pink tinge prior to hatching; the bolls are the favoured site for egg-laying. The larvæ (Plate 17; fig. 1), as already indicated, typically feed within the bolls and when full grown are salmon-pink in colour above except for the brown head and measure half an inch in length. When ready to pupate they cut a channel to the outside of the bolls, the holes formed being elliptical in shape. The larvæ then transform to the typical brown pupæ (Plate 17; fig. 3), pupation taking place both inside and outside the boll. Eventually the adult insects emerge and are then found to be inconspicuous greyish-brown moths (Plate 17; fig. 2) with a wingspread of about three-quarters of an inch.

Control.

Satisfactory control of this pest has been achieved by the adoption of three measures—firstly, the planting of seed containing no living

* *Platyedra scutigera* Holdaway.

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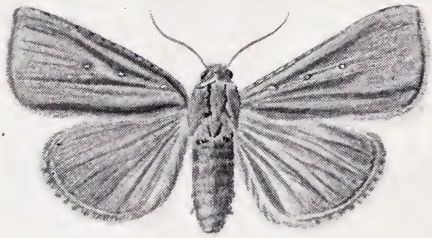

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I W. Helmsing
1935.

Plate 17.

PINK BOLL WORM, COTTON LOOPER, COTTON LEAF PERFORATOR, AND ROUGH BOLL WORM.

Face page 71.

pink boll worm larvæ; secondly, the virtual elimination of ratoon and standover cotton; and thirdly, the cleaning-up of cotton fields subsequent to the harvesting of the crop.

All cotton seed sown in Queensland is subjected to heat treatment in the Simon heater, the seed being exposed to a temperature of 140° F., thus ensuring the destruction of any pink boll worm larvæ present in the seed without in any way impairing its germinating capacity. This seed treatment is responsible for a material improvement in the pink boll worm position, but it cannot lead to the extermination of the pest. This is due largely to the fact that the pink boll worm breeds freely in certain species of hibiscus which are natives of the scrubs in the vicinity of the main cotton-growing districts. There is thus always a slight infestation creeping in from the wild hibiscus to the cotton areas bordering the scrub land, this being one of the reasons for the maintenance of the seed treatment.

The presence of ratoon or standover cotton is always a menace in so far as pink boll worm is concerned, for it affords an abundant supply of food for the pest early in the season, thus producing a heavy infestation for the main crop besides being itself subject to heavy attack and unlikely to produce a crop of any great value.

The third line of attack against this pest is the thorough cleaning up of all cotton fields, old plants, bolls and trash being destroyed by burning so as to eliminate any material in which pink boll worm larvæ may survive the winter to initiate an early infestation in the new season's crop.

ROUGH BOLL WORM.*

The rough boll worm is generally regarded as a cotton pest of very considerable importance, and, in one year, half the squares were destroyed by it on many farms in the Callide Valley. This species frequently destroys the terminal shoots of the plants, thereby stimulating the production of a plant of vegetative structure. The rough boll worm may also very seriously attack squares and flowers, while bolls of all sizes are also subject to infestation.

Life History and Habits.

The small bluish-white eggs are laid on the cotton plant, generally on the upper leaves or on the stems, and the larvæ (Plate 17; fig. 7) hatching therefrom feed on terminals, squares, and bolls. When full grown the rough boll worms measure three-quarters of an inch in length and are yellowish-grey except for a few darker marks, a green tinge appearing here and there on the body. Pupation takes place anywhere on the cotton plant, the usual moth pupæ being found within irregularly shaped greyish cocoons (Plate 17; fig 9) measuring half an inch in length. The moths (Plate 17; fig. 8) emerging therefrom belong to a distinctively marked species, the forewings being partly straw coloured,

* *Earias huegeli* Rozenk.

DESCRIPTION OF PLATE 17.

Cotton Pests.

Pink Boll Worm: Fig. 1.—Larva; Fig. 2.—Adult; Fig. 3.—Pupa. Cotton Looper: Fig. 4.—Adult. Cotton Leaf Perforator: Fig. 5.—Cocoon; Fig. 6.—Adult. Rough Boll Worm: Fig. 7.—Larva; Fig. 8.—Adult; Fig. 9.—Cocoon.

Figs. 5 and 6 × 3; all others × 2.

the rest of the colour scheme consisting of a large wedge-shaped greenish area extending from the base to the tip of each wing. The hindwings are silvery-grey fringed with a somewhat brownish tinge and the wingspread averages three-quarters of an inch.

Control.

Insecticidal control, as is the case with several other Queensland cotton pests, is still a matter for investigation. The elimination of ratoon crops and the cleaning up of cotton fields generally, which is considered essential for the control of other important insect enemies, should, however, lead to a reduction in the rough boll worm population.

COTTON WEB-SPINNER.*

The larvæ of the cotton web-spinner occasionally become destructively abundant in cotton, lucerne and maize being two other crops which may be seriously affected. Saltbush may also suffer severely, such infestation being occasionally a serious matter in districts wherein it constitutes an important fodder reserve. Bathurst burr, galvanised burr, roly poly, red pigweed, black pigweed, and hogweed are common weed host plants of this species.

Attacked foliage (Plate 18) is skeletonised or riddled and soiled by webbing and excreta. Seedling cotton may be killed, thus necessitating a replanting which may not yield a successful crop if the season is far advanced. Recovery of the seedlings, however, may take place if the infestation is not severe and conditions for recovery are satisfactory. Older plants may be defoliated or have their leaves riddled by the larvæ, and a few of the flowers and squares may also suffer injury. Such plants do not usually succumb to the attack, but cotton bushes eight weeks old have been killed.

Maize seedlings may be defoliated and killed, while the yield of lucerne may be seriously reduced, both in quantity and quality, by severe infestation of the growing tips.

Life History.

The small, flat, irregularly-rounded, yellow eggs are laid in bundles on the tips of host plants, as many as twenty occurring in one bundle. Egg-laying has not been observed on either cotton or maize, but occurs on lucerne and on weed host plants. Hatching takes place in two to four days in summer, and the quick-moving, slender, light yellowish-green or dark-green larvæ, which possess eight pairs of legs, become full grown in three weeks, eventually attaining a length of three-quarters of an inch. Pupation takes place in a silk-lined burrow in the soil, the burrow entrance being covered with a web of silk and debris. A typical brownish pupa half an inch in length is formed, and a week later the inconspicuous brown and fawn coloured moth appears. Its body length is slightly less than half an inch, the wingspread being nearly an inch. Quite a number of generations must occur each year, for the life cycle can be completed in summer in one month.

Control.

As egg-laying has not been observed on cotton, weed growth must play a very important part in outbreaks in that crop, infestation of the cotton being due to migration either from weed or cultivated host

* *Loxostege affinitalis* Led.

Plate 18.

COTTON WEB-SPINNER ATTACK.—Cotton leaf showing characteristic damage by web-spinner larvæ. Note the webbing and entangled frass.

plants growing outside the cotton field, or from weeds growing within it. A variety of factors, such as shortage of food or mechanical disturbance of the larvæ, are responsible for these migrations.

Migrations to cotton from weeds within the crop generally occur when weeds have been allowed to grow freely within the paddock and cultivation is undertaken when these weeds are infested with web-spinner larvæ. Infestation from outside the cotton usually originates by migration from weedy neglected paddocks in the vicinity thereof, although migration to cotton may also take place from lucerne.

It is obvious that cotton fields and their headlands should be kept as free as practicable from weed growth, and cotton should not be grown in the vicinity of weedy neglected paddocks. As a further incentive to the adoption of these precautions mention may be made of the fact that corn ear worm is frequently associated with migrations of the cotton web-spinner larvæ, there being a considerable similarity in their range of host plants.

Where potentially destructive migration has taken place within the field from weeds to cotton, much good can be accomplished by lightly swabbing infested cotton plants and weeds in the vicinity thereof with the swabbing mixture described on page 4. The mixture is applied sparingly to the plants by means of a whitewash brush or a bundle of twigs, all that is required being a light sprinkle on each infested plant. This swabbing is definitely helpful except in cases where the plants are only two or three weeks old. Then replanting is usually necessary because the seedlings are more or less destroyed before the cotton web-spinner larvæ have obtained a lethal dose of the swabbing mixture.

Where a migration from outside is observed before it has reached the cotton field, a furrow may be drawn and the ordinary cutworm bait scattered in the furrow and among and in front of the advancing larvæ. This procedure may also be adopted to protect a portion of a field not yet invaded. As an alternative to the cutworm bait, freshly cut weeds on which the web-spinner larvæ normally feed may be dipped in the swabbing mixture, and used to form a 6-inch high barrier in front of the line of advance of the larvæ. That portion of a field which has been invaded before the presence of the pest has been detected can be swabbed as already described; the swabbing in this case should extend 12 feet beyond the margin of infestation.

Maize may be protected in the same way from the larvæ of the cotton web-spinner migrating from outside sources. The part of the crop swabbed should not, of course, be used for silage or green feed. Both the baits and the swabbing mixture are highly poisonous and must, therefore, be used in such a manner that they do not contaminate any part of a plant required for feeding man or beast.

The protection of lucerne, on which egg-laying may freely occur, presents a difficult problem for the baits and the swabbing mixture already discussed cannot be used both effectively and safely in this case. Perhaps the best that can be done in an infested lucerne paddock is to immediately cut the crop if it is severely attacked.

Saltbush infestation presents an even more difficult problem than an attack in lucerne, and in this case there is as yet no known control measure which is effective, safe, and financially practicable.

COTTON LOOPER.*

The cotton looper frequently attacks the younger foliage on plants in various stages of growth; flowers and small squares at the growing tips may also be injured. Holes are eaten in the leaf tissue, and infested fields present a ragged appearance. Heavily foliaged fruiting types of plants can stand considerable defoliation, and some thinning out of leaves in such plants may even be beneficial, especially in a wet season. Foliage loss in lightly foliaged bushes, however, is quite another matter and may call for control measures.

Life History and Habits.

The active full-grown looper is about 1⅓ inches in length and is green in colour with two white stripes along the body. Darker specimens may also occur. It pupates near the base of the plant, and the rather drab moth (Plate 17; fig. 4) eventually emerges and lays its greenish-blue eggs on the foliage and squares.

Control.

Some action may be desirable in the case of small, lightly foliaged bushes. If their stunted condition is due to inefficient cultural methods or dense weed growth, the necessary procedure is obvious. Immediate attention to weed control may help considerably, but better cultural practices in the early stages of the development of the crop, designed to obviate the production of weakly growing plants, constitute the most practical method of avoiding severe injury from cotton looper attacks. However, if the small size of the plants is due to insufficient moisture, the use of the swabbing mixture, discussed on page 74 and elsewhere, or arsenate of lead or calcium arsenate dust at the rate of 5 to 7 lb. per acre may be considered, the decision regarding an attempt at control being governed by the economics of the position. The water in the swabbing mixture formula should be increased from 6 gallons to 12 gallons in cotton looper control.

COTTON LEAF PERFORATOR.†

The light-green cotton leaf perforator which, when full grown, is a quarter of an inch long, first excavates a short mine but later feeds on the leaf surface eating out characteristic shot holes, chiefly in the older leaves, which may be skeletonised. The larva forms a distinctive cocoon (Plate 17; fig. 5) from which the small grey moth (Plate 17; fig. 6) emerges. What has been said about the effect of cotton looper infestation applies also to this species which is, however, less important and seldom merits special control measures.

HARLEQUIN BUG.‡

The harlequin bug feeds on cotton bolls in all stages of development. Very young bolls are shed when attacked and this is a distinct source of loss, but it is not so serious as the attack on older bolls. Feeding proceeds in the manner common to all bugs, the bolls being pierced by the needle-like mouth parts and the plant juices sucked up through the punctures thus formed. Unfortunately, these feeding punctures (Plate 19; fig. 3) serve to admit fungous spores which, on development, produce a staining of the lint. Furthermore, the seeds, which

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* *Antarchæa chionosticta* Turn.

† *Bucculatrix gossypii* Turn.

‡ *Tectacoris lineola* Fabr.

are often penetrated by the piercing mouth parts of the bugs, also develop a fungous disease. The general effect of the infestation is thus a shedding of young bolls, the production of lint that is both stained and weak, the malformation and premature opening of bolls, and the poor germination of seed obtained from attacked bolls. The pest is one of some importance in cotton but cannot be regarded as being in the same highly destructive category as the corn ear worm. Nevertheless the boll rots following in the wake of the feeding of this insect may affect quite a high proportion of the crop late in the season.

Life History and Habits.

This insect is a prettily marked shield-shaped bug measuring three-quarters of an inch in length in the adult stage (Plate 19; fig. 2), yellow, orange, scarlet, metallic blue, and metallic green constituting the various colour patterns. The adults make their appearance in the cotton crop just about the time it commences to flower, the migration to the crop generally being spread over a period of several weeks. The eggs (Plate 19; fig 1) are laid on cotton in clusters of as many as 120 and generally completely encircle the twig or the leaf stalk chosen as the egg-laying site. The comparatively large barrel-shaped eggs hatch out in two or three weeks and the nymphs or immature bugs which emerge from them display a marked tendency to feed in clusters more particularly during the early stages of their development. They moult five times and their colour patterns are formed from blue, green, and red, the adult stage being reached ten or eleven weeks after hatching. Both the nymph and the adult feed on the cotton bolls, the length of the adult life being about three months.

Control.

The adult bugs, their egg masses, and their gregarious nymphs are all very conspicuous in a cotton field, hence hand picking and destruction of these various stages can be carried out with a considerable degree of efficiency. The best procedure is to keep a careful watch for the migration of these adults from the bottle trees, kurrajong trees, and hibiscus bushes which are their native host plants. This movement should normally take place during the months of November and December, and the prompt destruction of these migrants should preclude any probability of their breeding up in large numbers to cause a serious incidence of boll rots late in the season.

COTTON STAINER.*

The cotton stainer attacks the green bolls, feeding on them in much the same way as does the harlequin bug. It, however, manifests a very marked preference for the seed and accordingly congregates in numbers in the open bolls or on bolls which are just splitting open. Staining of the lint and injury to the seed with reduction in its germination and oil-yielding capacity are features of cotton stainer infestation, boll rots following in the wake of its attacks.

* *Dysdercus sidæ* Montr.

DESCRIPTION OF PLATE 19.

Cotton Pests.

Harlequin Bug: Fig. 1.—Eggs × 1¾; Fig. 2.—Adult × 1¾; Fig. 3.—Feeding punctures, half natural size. Cotton Stainer: Fig. 4.—Egg × 12; Fig. 5.—Fifth stage nymph × 1¾; Fig. 6.—Adult × 1¾. Cotton Seed Bug: Fig. 7.—Adult × 8. False Stainer: Fig. 8.—Fifth stage nymph × 1¾; Fig. 9.—Adult × 1¾.

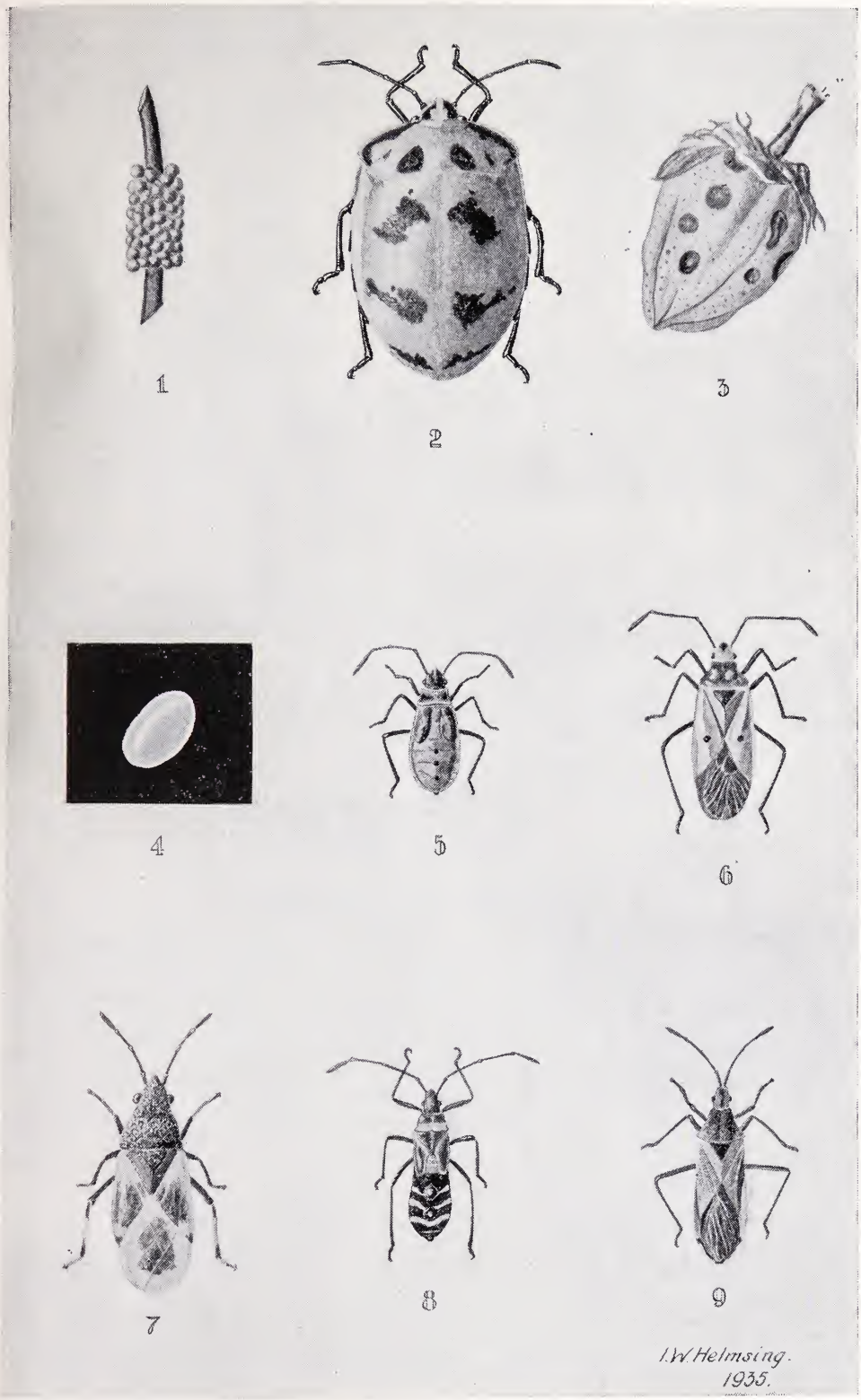

Plate 19.

HARLEQUIN BUG, COTTON STAINER, COTTON SEED BUG, AND COTTON FALSE STAINER.

Face page 76.

Life History and Habits.

The very small somewhat oval eggs (Plate 19; fig. 4) are laid immediately under the soil surface or under the shelter of a clod, a stick or other debris, a number of eggs being laid at each egg-laying site. The stainer lays from 500 to 600 eggs altogether, and these pearly-white eggs hatch in five or six days, the eggs assuming an orange tinge towards the end of the incubation period. The newly emerged bugs are orange-red in colour, but they become red and black after the first moult, while in the later stages (Plate 19; fig. 5) white appears in the colour scheme. The nymphs moult several times, the winged adult stage being reached four weeks after hatching from the eggs. The adult stainers (Plate 19; fig. 6) are half an inch in length, the upper surface of the body, when the wings are at rest, being predominantly brownish-grey or reddish-brown, the tips of the wings being dark-brown, while a conspicuous dark-brown or black spot occurs in the middle of each forewing. Naturally, during the colder weather development is much retarded. The stainer feeds on bottle trees, kurrajong trees, hibiscus bushes, and various weeds closely allied to cotton, and from these it migrates to the cotton fairly late in the season.

Control.

Here again a thorough clean up of the cotton fields followed by the burning of the plants and all cotton and other debris will be productive of much good, for it will be found that most of the cotton stainers congregate in the heaped-up cotton bushes. When these are dry enough to burn, the associated stainers will be destroyed by the flames and the following season's crop should be practically free from infestation until the annual summer migration from the wild host plants commences. Obviously standover and ratoon cotton should be avoided, for its presence merely serves to give the cotton stainer a much earlier foothold in the cotton than would otherwise be possible.

COTTON FALSE STAINER.*

The adult false stainer (Plate 19; fig. 9), which has a reddish-brown and black colour pattern, is about the same size as the stainer, but it has no dark-brown or black spots on the wings. The nymph emerging from the small bronze egg laid in groups of as many as ten or twelve on any part of the plant is mainly black in colour. This species causes some loss by puncturing squares and young bolls, which are subsequently shed. Special control measures are unnecessary, but the normally desirable attention to field hygiene will be helpful against this pest.

COTTON SEED BUG.†

The adult black cotton seed bug (Plate 19; fig. 7) is about an eighth of an inch in length and has clear wings, except for a dark area on each of the forewings. It feeds on the seed in mature or insect attacked bolls and the lint is stained and the oil content reduced as a result of its feeding activities. Seed cotton may also be stained by the crushing of nymphs and adults during picking and packing. Special control measures are not called for.

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* *Aulacosternum nigrorubrum* Dall.

† *Oxycarenus arctatus* Walk.

COTTON JASSIDS.*

Several species of leafhoppers or Jassids have frequently been responsible for a serious diminution in cotton yields in the Upper Burnett, and in a recent season they also became extremely abundant in the Callide and Dawson Valleys. Yield reduction in that season's crop was largely a result of their abnormal abundance, infestation being particularly serious on the reddish-brown soils of softwood scrub areas. Both the adult and the immature stages of these leafhoppers feed on the foliage, extracting the sap therefrom through punctures made by their mouth parts. Infested leaves show a marked yellowing, working in from the leaf margin, which is best viewed from the under surface; with it there is usually associated a reddish-brown discolouration on the upper surface. The older leaves often bear many small white blotches on the upper surface, and these leaves, when attacked, may be slightly curled downwards, a symptom which is much more pronounced in the younger infested leaves. Much of the leaf tissue may die and become infected with fungous growths, and eventually extensive loss of foliage may occur. Seedling growth may be retarded, particularly in dry weather, and heavy infestation later in the season produces a shedding of squares and reduces the quality of the lint in the younger bolls. There is thus a great reduction in the yield of cotton, particularly in the case of late planted crops.

Life History and Habits.

The cotton leafhoppers are active little insects possessing the power of jumping short distances when disturbed, and of moving sideways in a characteristic fashion. The commonest of the species associated with cotton is a greenish torpedo-shaped insect with two pairs of wings closely folded over the body. It measures slightly more than one-eighth of an inch in length, but the immature stages, which of course are wingless, are much smaller. The leafhoppers breed on the undersides of the leaves on any type of cotton plant, but they appear to multiply most freely on the sappy quick-growing type which incidentally also seems to react most seriously to infestation. Breeding continues while the plant growth is fresh, but slows up as the crop acquires the reddish-brown appearance so characteristic of the advanced stages of a severe infestation. This species also attacks tomatoes and potatoes.

Control.

The cotton leafhoppers constitute a particularly difficult problem in control. The use of insecticides appears to offer little prospect of success, and it would seem that the breeding of resistant varieties constitutes the most promising line of attack against these insects. That is naturally a long distance project from which quick results cannot be expected. Fortunately the leafhoppers have so far been a general cotton problem in one season only.

COTTON STALK GIRDLING BEETLE.†

The cotton stalk girdling beetle occasionally attacks cotton and may inflict serious losses in restricted areas, but fortunately no widespread outbreak of this pest has ever been recorded. This beetle may attack foliage, but, as its common name indicates, it characteristically eats the soft surface tissue of the stalks of the cotton leaves and similarly attacks the lateral and main shoots. The attacked leaves and shoots collapse

* *Empoasca* spp.
† *Rhyparida australis* Boh.

and die if the girdling has been at all extensive, and attacked cotton bushes present a wholly or partially defoliated and bedraggled appearance.

Life History and Habits.

This pest is a small dark-brown or black sturdily built beetle measuring a quarter of an inch in length and an eighth of an inch in width. Little is known of the life history of the species except that it occasionally appears in large numbers in cotton, small plants carrying as many as thirty beetles apiece. Such a population is quite capable of defoliating a plant when its feeding habits are largely restricted to the girdling of leaf stalks and shoots.

Control.

Like the red shouldered leaf beetle, this species comes to light quite readily and the flares, recommended for the control of that pest, can also be employed with a considerable measure of success against the cotton stalk girdling beetle.

PASPALUM WHITE GRUBS.*

White grubs are responsible for injury to paspalum grass in a number of dairying districts, but appear to cause heavier losses on the Atherton Tableland than elsewhere, the main centre of infestation being Peeramon, where an area of 25,000 acres of dairying country is subject to attack by a native species with consequential serious reduction in its carrying capacity. A second species causes losses in the vicinity of Atherton, but is of much less importance than its Peeramon relative. Both species feed in the soil on the roots of grasses, and as a consequence patches of grass assume a sickly appearance and dry off. These symptoms of infestation are most noticeable in autumn and winter when the vigour of the grasslands is at its lowest ebb. The patches slowly enlarge and eventually practically the whole paddock may be affected, the infested soil becoming granular as a result of being passed through the alimentary canal of the white grubs and expelled as pellets. The dead or dying grass often loses all contact with the surface soil and can be brushed or raked therefrom with little effort.

Life History and Habits.

The clumsy brown beetles to which the white grubs eventually transform emerge from the soil between October and January, their emergence being facilitated by the advent of spring storm rains which soften the soil. The beetles emerge at dusk and fly to trees, stumps, fences, or buildings whereon they mate. When returning to the soil many of the beetles do so in the vicinity of the obstacles on which they mated, hence the frequent concentration of infestation near stumps or along fences. This is also a possible partial explanation of the noticeable lack of serious infestation in many cultivated paddocks which are generally practically free from tree stumps. The grubs hatching from the eggs laid by these beetles are typical of their class, being soft white fleshy grubs with reddish-brown heads and three pairs of legs. Their growth is accompanied by a series of moults and when full grown they pupate in the soil in winter at a depth as great as 2 or 3 feet. Pupation takes place during the second winter after the grubs hatched from the eggs, the species thus possessing a two-year life cycle. It is interesting to note that the damage is particularly severe during the second year of the pests' larval existence; hence years of severe and slight loss tend to alternate.

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* *Lepidiota caudata* Blkb. and *Lepidiota lævis* Arrow.

Control.

The economics of dairying are such that any insecticidal control—*e.g.*, soil fumigation—may at once be ruled out as utterly impracticable, no matter how high a mortality of the grubs may be achieved thereby. Some other mode of attack must therefore be adopted, and in connection therewith it is important to note that deterioration of carrying capacity has occurred quite irrespective of the white grub factor; hence it seems desirable, from a purely cultural point of view, that mixed farming should gradually replace grassland farming in the affected areas. It is believed that such a change over would assist in the restoration of fertility which would also tend to reduce the seriousness of the incidence of the grub infestation. Furthermore, it would provide a supply of the winter feed so necessary to supplement the relatively poor grass available in winter, the quantity and quality of which is at present still further reduced by grub attack.

GRASS GRUB.*

The paspalum white grubs, dealt with in the preceding paragraphs, are the immature stages of clumsy brown beetles, whereas the grass grub to which the reader's attention is now directed develops into a large moth. Both white grubs and the grass grub attack the pastures of the Atherton Tableland, the grass grub occuring in pest proportions chiefly in close proximity to unfelled rain forest areas, while the occurrence of the paspalum white grubs, which reach their maximum abundance in the older cleared areas, does not appear to be dependent on such an association of farmland and forest, at least on the Tableland. Furthermore, the white grubs, deriving their food as they do from the roots of paspalum and other grasses, spend the whole of their larval life in the soil feeding and sheltering therein, whereas the grass grub merely shelters in the soil, emerging from its earthen burrows to feed on the leaf blades and stems of grasses. Large areas of pasture land may be more or less denuded of grass as a result of the presence of this pest, which may persist from year to year on the same farm, thereby greatly reducing its carrying capacity. Nearly all species of grasses are subject to attack, although a certain preference is displayed for paspalum, Kikuyu, carpet grass, and yellow grass. The grass grub is indigenous to the rain forest in which it feeds mainly on fallen leaves.

Life History and Habits.

The moths of the grass grub are plentiful during the first quarter of the year, and the larvæ or grubs hatching from their eggs may be found in large numbers until the end of the year. These larvæ shelter in somewhat vertical burrows which reach to a depth of from 6 to 15 inches, the upper portion of the burrows being lined with silk. Some idea of the intensity of infestation may be obtained from the fact that an average of twenty-five burrows per square foot occurred on one heavily infested area. The slender larvæ when full grown measure at least 2 inches in length and are dark-green in colour. They pupate at a depth of 4 to 6 inches, pupæ occurring during the months of December, January, February, and March. The moths emerging from these pupæ are predominantly brown, there being no pronounced colour pattern such as is so frequently found in other species of moths. The wings are somewhat narrow, and the body is slender, the wingspread being about $1\frac{3}{4}$ inches.

* *Oncopera mitocera* Turn.

Control.

The control of this pest presents many practical difficulties, the insecticidal avenue of approach offering no prospects of success. There is, however, a considerable body of evidence supporting the belief that areas badly infested in earlier years now suffer little or no loss, the improvement therein being associated with a steady increase in the distance separating these areas from uncleared rain forest. It is therefore hoped that with the expansion of settlement on the Tableland this pest will become of steadily lessening importance in so far as the district as a whole is concerned.

PASPALUM MEALY BUG.*

A species of mealy bug has sometimes been found in large numbers on paspalum in southern dairying districts, the upper portions of infested plants dying off as a result of the attack, which may involve several acres in each of a number of paddocks, infestation being restricted to the northern slopes of the ridges. The tips and margins of the leaves assume a purplish tinge, which steadily extends and is accompanied by a marked marginal crinkling of the leaf, the plants eventually becoming quite brown and apparently lifeless. The early purplish symptoms may be a manifestation of the presence of adverse factors other than mealy bug infestation, but if the mealy bug is responsible for the trouble, that fact can be easily ascertained by an examination of the leaves and stalks of the sickly plants. Should it be the culprit, the mealy bug will be found close to the base of the leaf stalk which is frequently smothered in the white mealy secretions of the insect, as many as thirty of which may be found on a single plant.

Life History and Habits.

The adult female mealy bugs are about one-quarter of an inch in length, possess well-developed legs, are slug-like in appearance, and are covered with a white floury secretion, thus masking the creamy colour of the elongate oval bodies. A further characteristic feature of the adult females is the presence of a large number of slender white filaments on the sides and upper surface of the body. These measure one-quarter of an inch in length, but are mostly shed when the females are about to commence reproducing. The young mealy bugs of which 250 may be produced by one female emerge enclosed in a membrane which is soon ruptured, the young bugs escaping therefrom half an hour later. They then feed by sucking the sap, generally close to the underside of the midrib of a leaf, and are at first dirty-green in colour and measure one-seventy-second of an inch in length. The floury secretion and the filaments soon appear and eventually most of the immature bugs become adult females, there being little difference in appearance between the latter and well-grown larvæ. The adult male is a delicate two-winged insect quite unlike the adult female, and is not likely to be encountered by the farmer. It measures one-thirty-second of an inch in length and, unlike the female, it goes through a definite pupal period, the male larval stage differing in some respects from that of the female. A single generation of this insect can be completed in about ten weeks.

* Generic and specific identification not available.

Control.

Insecticidal control of this pest is considered impracticable, but it may be satisfactorily dealt with along other lines. In the first place the reader is reminded that quite a number of insects of the family to which the paspalum mealy bug belongs show a marked preference for plants deficient in vigour, and in this connection it is worthy of note that many of the paspalum paddocks in Queensland dairying districts have received little or no cultural attention since they were laid down many years ago. The carrying capacity of these paddocks has naturally undergone marked deterioration, the plants therein being noticeably root bound and of a somewhat sickly appearance. It is further worthy of mention that all paddocks in which the paspalum mealy bug has been found doing appreciable damage are included in this category. It is therefore considered that a restoration of the pastures to something approaching their original healthy condition will go far towards reducing losses from paspalum mealy bug, and it is accordingly suggested that badly infested paddocks be burned off and then ploughed to a depth of 4 inches, thereby breaking up the old root-bound clods and exposing the soil to the beneficial influence of the sun and the air. The ploughing should be followed by a light harrowing and such pasture renovation should normally be undertaken during the rainy season. The burning and cultivation will kill off many of the mealy bugs, and, as already indicated, should produce a pasturage much better fitted to withstand the attacks either of survivors or of any individuals which may migrate to the renovated areas from other infested paddocks.

ARMY WORMS.*

Army worm outbreaks occasionally occur in grazing and farming areas. Several species may be represented in such outbreaks, but their general habits are very similar. The stout-bodied parent moths are of the cutworm type (Plate 11; figs. 5 and 6) and measure about three-quarters of an inch in length. Their eggs are laid in clusters on foliage or on the ground, and the caterpillars emerging from them are about one and a-half inches in length when full grown. Pupation then takes place in the soil. The first stage of an attack is a dense clustering of young caterpillars or army worms which feed outward from local centres of infestation; later they change formation to long lines, bands or armies of caterpillars feeding across the land and denuding it of any suitable host plants. Pasture grasses and crops such as wheat, maize, giant setaria, sorghums, Japanese millet, and Sudan grass may be attacked. Young crops may be completely eaten out, but the severity of damage and the rate of invasion are less in older crops.

Normally, an attack lasts for one generation, towards the end of which natural enemies become fully operative. Nevertheless, so much injury may occur in a short time that early application of an insecticide is usually desirable. The cutworm bran bait described on page 3 may be thinly broadcast by hand over and for a few feet in front of the lines of advancing caterpillars. The amount of bait prepared from 50 lb. dry weight of bran should be sufficient for one acre of baited ground. The furrow method of baiting, described on page 56, may also be adopted. The bait is poisonous to stock, and, although the correct thin distribution renders it reasonably safe, such a mixture is sometimes undesirable. As an alternative, the strip of fodder plants

* *Cirphis loreyi* Dup., *C. unipuncta* Haw., *Spodoptera exempta* Walk., and *S. mauritia* Boisd.

or pasture that is heavily infested by army worms may be sprayed with the crude oil emulsion referred to on page 8. This insecticide will kill both the caterpillars and the treated portions of the plants, but it does not contain any dangerous stock poison.

RICE WEEVIL.*

A small dark-brown weevil has long been known as a pest of rice, and as it was first recorded from that crop it was and still is generally referred to as the rice weevil. To Queensland farmers, however, its importance is due to its association with maize and wheat, more particularly with the former. This insect shows a marked preference for tropical and subtropical regions, while a very closely allied species, known as the granary weevil,† attains its maximum abundance in temperate zones. Maize and other susceptible grains may be attacked by generation after generation of weevils when stored for prolonged periods, and may thereby be reduced to a valueless mass of fragments. Infestation of maize is a more or less chronic state of affairs in Queensland, but this is not so with wheat, for if that crop is harvested in a normally sound and dry condition and is so maintained when stored it will probably remain commercially free from attack. This is largely due to the fact that the rice weevil does not breed freely in grains with a low moisture content. Much of the wheat harvested in Queensland has a moisture content that is too low for the successful breeding of the rice weevil, but precisely the opposite is the case with a large proportion of the maize, hence the difference in incidence of infestation. Furthermore, infestation frequently commences in growing crops of maize, whereas that is not so in the case of wheat; hence although wheat stored under adverse conditions may be severely damaged, losses therein are much less common than in maize. Grain products such as macaroni and biscuits may also be seriously infested.

Life History and Habits.

The hard-bodied dark-brown rice weevil measures one sixth of an inch in length, and possesses the typical downwardly pointed weevil snout, the back of the insect bearing four reddish-brown spots. The weevil may live for four or five months, and has been known to lay 400 eggs during that period. It gouges a very small cavity in the surface of the grain selected for egg-laying, and therein it deposits a single egg. A few days later the white, legless larva hatches and feeds within the grain, becoming full grown two or three weeks later. It then pupates, and at the end of a week the weevil, which is the adult stage in the life cycle, emerges from the pupa, leaves the grain in which the larval stages have been spent, and, after mating, proceeds to lay a batch of eggs, thus launching the new generation. The life cycle may, therefore, be completed in less than a month in the height of summer, and although a considerably longer developmental period is required in the colder months, it is thought probable that six or seven generations may occur annually in coastal Queensland. The larva is responsible for most of the damage, but the weevils also nibble the grain, and thus assist the work of destruction. The life history of the granary weevil, which is of less importance in Queensland, is somewhat similar. It is slightly larger than the rice weevil, from which it may be separated by the fact that it possesses no reddish spots on the back. Furthermore, the rice weevil flies freely, whereas the granary weevil is unable to do so.

* *Sitophilus oryzæ* L.

† *Sitophilus granaria* L.

Control.

Control of the rice weevil will be discussed under two headings, firstly minimisation of crop infestation in the field, and secondly protection of harvested grain from attack while stored, it being understood that in this discussion consideration is being given mainly to maize.

The first point of importance to be noted in dealing with weevil infestation of growing crops is that the rice weevil does not generally eat through maize husks; therefore, other things being equal, the maize grower should plant a variety possessing a long, closely-fitting husk. Furthermore, the maize crop should be harvested as soon after reaching maturity as is practicable, thereby reducing the period of exposure to field infestation. Another important control measure is the reduction of sources of infestation by destroying as much waste maize material as possible, giving attention to both the barn and the field. The rice weevil can breed freely in such waste material, thus maintaining its existence on the farm between successive crops of maize. The weevils so produced will fly from barns or fields to infest the new crop, hence the importance of eliminating waste material to cut off sources of field infestation.

When the grain has been harvested and stored weevil infestation may be dealt with by carbon bisulphide fumigation, which is fully discussed on page 13. A second fumigation may be necessary after an interval of two or three weeks in cases where the infestation is severe. After fumigation the maize should be stored in clean, closely-sealed containers in order to reduce the chances of reinfestation. Finally, mention may be made of the fact that a small quantity of a mixture of equal parts of flake naphthalene and paradichlorobenzene affords some measure of protection to small quantities of grain retained for seed purposes. As well as being toxic it acts as a repellant, and the rice weevil shows a disinclination to infest seed to which a small quantity of the mixture has been added.

PEA AND BEAN WEEVILS.*

Various species of beetles attack peas and beans, and are generally referred to as pea and bean weevils, although they do not really belong to the weevil family. They are small, broadly built insects in which the elongate, downwardly directed snout that is such a prominent feature in the weevils is absent. These species are brownish or reddish-brown in colour, with grey, white, and dark-brown or black patches on the back, and measure from one-fifth to one-eighth of an inch in length. Their small white larvæ feed voraciously in the seeds of peas and beans, cowpea being frequently heavily infested in this State. When the beetle is ready to leave the seed in which it has transformed through the pupal stage from the larva, it eats a circular clean-cut hole through the seed coat and thus emerges. Generation after generation of these weevils may breed in cowpea, finally destroying the whole stock if steps are not taken to deal with the infestation. Fumigation with carbon bisulphide will, however, adequately deal with these pests. The same quantities of carbon bisulphide should be employed as are used against the rice weevil in maize, but in the case of cowpea and allied seeds it is generally considered that the duration of the fumigation period should be only twenty-four hours.

* *Bruchidæ.*

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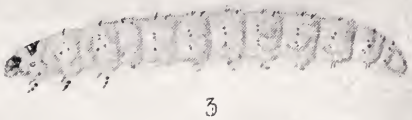

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I. W. Helmsing 1930.

Plate 20.
POTATO TUBER MOTH.

Face page 85.

Chapter IV.—VEGETABLE PESTS.

This chapter is devoted to the consideration of the more important vegetable pests, the following insects being discussed:—potato tuber moth, cabbage moth, centre grub, cabbage cluster grub, cabbage aphis, brown vegetable weevil, green vegetable bug, onion thrips, leaf-eating ladybird, bean fly, pumpkin beetle, sweet potato weevil, and tomato mite. The last-mentioned species is the only insect dealt with solely as a tomato pest in this volume, the corn ear worm or tomato worm and the brown cutworm having been dealt with in the preceding chapter because of their great importance as pests of cotton, tobacco, maize, and lucerne.

POTATO TUBER MOTH.*

The tuber moth, which is the world's most serious pest of potatoes, occurs wherever they are grown in Queensland. It is also a notorious enemy of tobacco, being known to growers of that crop as the tobacco leaf miner. Its association with tobacco, however, is dealt with on page 63 in the chapter devoted to agricultural and grassland pests, the present discussion being confined to the insect's activities as an enemy of the potato.

Life History and Habits.

The minute, oval, white, iridescent eggs (Plate 20; fig. 1) are deposited on leaves, stalks, and tubers, and may even be found on sacks containing infested potatoes. The eggs on the tubers are laid in batches at the eyes (Plate 20; fig. 2) or in surface scars, but on the leaves they occur singly and usually on the under surface, a total of 200 eggs being laid over a period of about two weeks by a single moth. The incubation period varies greatly, larvæ emerging from eggs laid in midsummer in three to five days, while in midwinter in North America an incubation period of almost five weeks has been recorded. The larvæ on hatching commence tunnelling within the leaf if the eggs have been laid thereon, and the destruction of the tissue between the upper and lower surfaces can soon be detected in the form of blotch mines, these later becoming brittle discoloured patches of dead tissue. The larvæ hatching on the tubers either tunnel under the skin or work their way to the heart of the potato. (Plate 20; figs. 8 and 9). The tunnels may be 2 or 3 inches in length, and obviously, burrowing in the heart of the tuber is the most serious form of attack, large consignments of potatoes being frequently ruined thereby. The larvæ (Plate 20; fig. 3) are full grown at the end of two weeks in summer, and then measure half an inch in length, and are predominantly white in colour with a slightly pinkish or greenish tinge on the upper surface. They generally pupate in silken cocoons on the outside of the tubers, in folds of sacking, among dead leaves, or under lumps of soil. Occasionally, however, the dark-brown pupæ (Plate 20; figs. 5 and 6), which

* *Phthorimæa operculella* Zell.

DESCRIPTION OF PLATE 20.

POTATO TUBER MOTH.

Fig. 1.—Egg × 35.
Fig. 2.—Eggs on tuber surface × 10.
Fig. 3.—Larva, lateral view × 4.
Fig. 4.—Cocoon covered with soil particles × 2½.
Fig. 5.—Pupa, ventral view × 7.
Fig. 6.—Pupa, lateral view × 7.
Fig. 7.—Adult × 4.
Fig. 8.—Tuber showing external signs of infestation, half natural size.
Fig. 9.—Tuber showing tunnelling, half natural size.

are one-third of an inch in length, occur at the entrance of the tunnels in the tubers. Although silk is used in weaving the cocoons, any parts that would otherwise be exposed are usually covered by particles of earth or debris; hence the silken nature of the cocoons is obscured. Eventually the inconspicuous moths (Plate 20; fig. 7) emerge after a pupal period of about one week during the warmer weather, and are seen to be greyish-brown in colour with a wingspread of half to three-quarters of an inch. Quite a number of generations of this pest are produced in the course of the year.

Control.

The first step in the control of the potato tuber moth is the safe-guarding of the tubers in the soil. The seed potatoes should, therefore, be planted as deeply as practicable, the plants should be well hilled up, and the surface soil thoroughly pulverised. The procedure just outlined materially assists in reducing infestation of the tubers during the growing period, as it minimises the chances of the pest gaining access to them. At harvesting, the potatoes should be bagged, and the bags sewn up and removed from the field as soon as possible. The potatoes should never be left exposed overnight in the field, for if that is done thousands of eggs may be laid on the tubers, and severe infestation inevitably eventuate during storage. Furthermore, the potatoes should never be covered with the tops, as these are frequently heavily infested with the larvæ of the moth and these speedily migrate to the potatoes from the fast-withering foliage and stalks. The tubers should preferably be placed in new bags, but if the containers have been previously used for the storage of potatoes they should be immersed in boiling water to ensure the destruction of any potato tuber moth larvæ, pupæ, or eggs which they may be harbouring. Whenever it is practicable to do so the tubers should be placed in a store to which the moth cannot readily gain access. Finally, in cases where infestation has occurred, carbon bisulphide fumigation at the rate of 4 lb. of the fumigant to 1,000 cubic feet of the container will be found to be productive of beneficial results. The fumigation, the duration of which should be thirty-six hours, may require repetition should reinfestation occur. Fumigation at the strength indicated will kill the moths and larvæ, and will dispose of most of the eggs and pupæ.

CABBAGE MOTH.*

The larvæ of the common cabbage moth occur wherever that vegetable is grown in Queensland and successful production is rendered possible only by the regular application of insecticides. Three other species of caterpillars may also attack cabbages, namely, the centre grub, the notorious corn ear worm, and the cabbage cluster grub.† As its name implies, the centre grub characteristically feeds in the growing centre of the young plant. The corn ear worm, on the other hand, has the habit of burrowing right through into the heart of well-formed heads of cabbages. The third species, the cabbage cluster grub, is of much less importance, although, on occasion, a number of these caterpillars, feeding under the slight shelter of faint webbing, may destroy the developing heart leaves of young cabbages. The larvæ of the common species are often referred to as green wrigglers, and as they are far

* *Plutella maculipennis* Curt.

† *Crocidolomia binotalis* Zell.

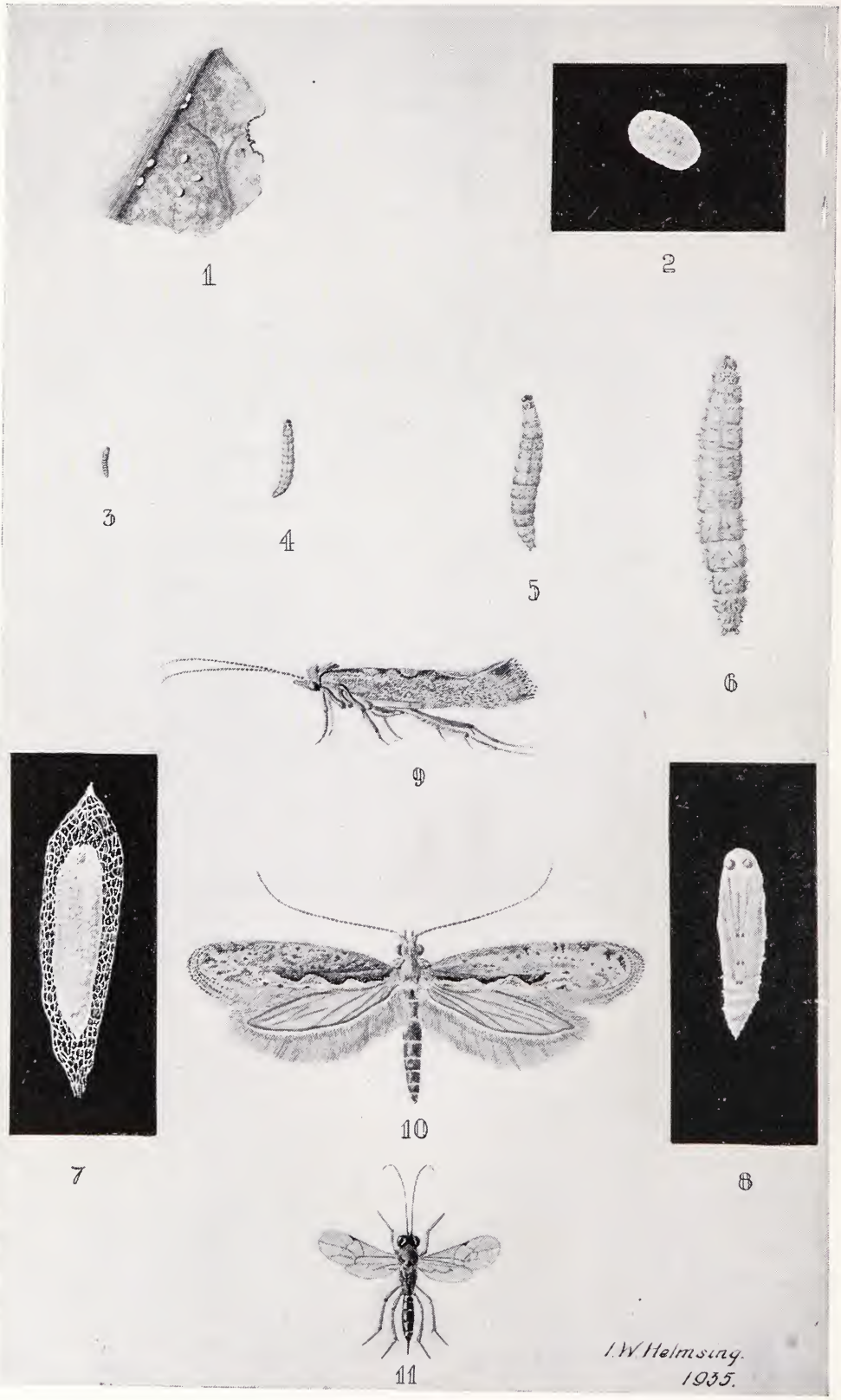

Plate 21.
CABBAGE MOTH.

Face page 87.

commoner than the other three just mentioned the moths to which these green wrigglers give rise are generally and rightly referred to as the cabbage moth. The life history, habits, and control of this species will now be discussed in some detail, briefer reference being made to the centre grub and the corn ear worm in subsequent paragraphs.

Life History and Habits.

The moth (Plate 21; figs. 9 and 10) is a small greyish-brown species with rather a pretty wing pattern, the wingspread being about two-thirds of an inch and the body length slightly less than half an inch. It often occurs in enormous numbers in a cabbage patch and is readily disturbed in walking among the plants, the moths darting about in short flights. It lays its oval yellow eggs (Plate 21; figs. 1 and 2), which are just visible to the naked eye, on the leaves of cabbages, cauliflowers, and a number of other vegetables, the eggs being laid singly or in pairs on the under surface of the leaves, generally in proximity to the larger leaf veins. After a brief incubation period the very small colourless caterpillars emerge and feed on the under surface of the leaf, the upper surface being left intact. However, as the green wrigglers grow they eat right through the leaf which may eventually be riddled by numerous more or less circular holes. The larvæ (Plate 21; figs. 3-6) are slender active green caterpillars which are rather spindle-shaped and measure about half an inch in length when full grown. Their habit of falling with a jerking motion from the leaves when disturbed and hanging therefrom by a thin silken thread has earned for them the common designation of green wrigglers. The full grown wrigglers pupate in lace-like cocoons (Plate 21; fig. 7) of great beauty, the pupæ (Plate 21; fig. 8), pale green at first but later darkening to brown, being clearly visible through the open strands of the cocoons. At the end of the pupal period the moths emerge and so another generation is initiated.

Control.

Spraying or dusting with insecticides is essential for the control of this pest, applications being made at frequent intervals preferably every seven days when the plants are in the field. As serious damage may be inflicted in the seed-beds the seedlings should also be treated, and in their case the application should be made every second day. It is necessary to emphasise the fact that one or two applications are unlikely to be productive of any appreciable good, hence the cabbage grower should include spraying or dusting as a regular routine in cabbage production. Furthermore, the spraying or dusting must be thoroughly done, the under sides of the leaves being as well coated as practicable.

Arsenate of lead was formerly largely employed for cabbage moth control, but this insecticide has rather fallen into disrepute because injurious toxic residues were all too frequently associated with cabbages marketed after spraying or dusting with this arsenical. However,

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DESCRIPTION OF PLATE 21.

CABBAGE MOTH.

Fig. 1.—Eggs in situ × 5.
Fig. 2.—Egg × 24.
Figs. 3-6.—1st, 2nd, 3rd, and 4th stage larvæ × 5.
Fig. 7.—Cocoon and pupa × 5.
Fig. 8.—Pupa × 5.
Fig. 9.—Adult (lateral view) × 5.
Fig. 10.—Adult (dorsal view) × 5.
Fig. 11.—Larval parasite × 4.

numerous experiments have demonstrated that derris sprays give an even better control of cabbage moth caterpillars than arsenate of lead, and growers are accordingly advised to use a reliable brand of derris for the control of this serious pest. Derris dusts have also given promising results in preliminary trials, but they have not yet been so extensively tested as the derris sprays. Nevertheless, observations of results obtained by growers using derris dusts indicate their adequacy for the control of the cabbage moth.

Some assistance in controlling cabbage moth may be obtained by strict attention to farm hygiene. The disposal of unmarketable cabbages and the residues of marketed cabbages may admittedly present difficulties, but, nevertheless, in so far as it is practicable to do so, this material should be destroyed, thereby eliminating considerable quantities of plant tissue on which the moth can breed. Finally it may be pointed out that plantings should be restricted to areas to which efficient and regular attention can be given and so far as practicable successive plantings should not be adjacent to each other.

CENTRE GRUB.*

The cabbage moth is in evidence all the year round in Queensland but the centre grub is primarily a pest of the summer months. It burrows into the growing centre of the plant and tunnels in the main stem, the young leaves of attacked plants being closely webbed together. When tunnelling of the stem takes place in a young plant it generally succumbs to the attack. At a later stage in growth, however, death does not ensue, for although the main growing bud may be destroyed side shoots appear and if all but the best of these side shoots are immediately removed a marketable cabbage may be produced. A further feature of this grub's feeding in severe infestations is tunnelling in large leaf veins in the older plants. These tunnels occur in leaves resting on the ground or in close proximity thereto and soil particles are often webbed together to complete the tunnel. The full grown centre grub is a pale-yellow caterpillar slightly more than half an inch in length, the colour pattern being elaborated by the presence of seven brownish longitudinal stripes. The grub pupates in its tunnel, and eventually the small pale, fragile, brown and grey coloured moth emerges. The measures outlined for the control of the cabbage moth will also be found effective against the centre grub.

The corn ear worm may occasion considerable damage in cabbages, more particularly in late summer and autumn, its characteristic mode of attack being to tunnel towards the heart of the cabbage. The life history and habits of this well known insect will be found fully discussed on page 59. With respect to its incidence in cabbages the position is that no really satisfactory spray is available for dealing with this pest, although the derris used for cabbage moth and centre grub control may be slightly beneficial.

CABBAGE APHIS.†

Another common cabbage and cauliflower pest is the cabbage aphis which may form very dense colonies on both surfaces of the leaves, these becoming malformed and unsavoury in appearance. The young aphids are green in colour, but the older individuals in a colony are

* *Oebia undalis* Fabr.

† *Brevicoryne brassicæ* L.

greyish-blue insects covered with a white waxy bloom. Like all aphids this species is a soft-bodied slow-moving insect feeding by sucking the sap of the plant on which it lives, thereby greatly weakening its host, which becomes stunted and sickly and may even succumb to the attack if the infestation is particularly heavy.

Control.

The experiments conducted to test and demonstrate the value of derris sprays for the control of the cabbage moth also showed that these insecticides are highly effective for the control of cabbage aphis; hence the spraying programme for dealing with the one pest should also more or less automatically control the other.

BROWN VEGETABLE WEEVIL.*

The brown vegetable weevil is a comparatively recent arrival in Australia, but in the last few years it has become firmly established in Queensland, each year witnessing a steady increase in the infested territory. It has a very wide range of host plants, those most favoured being potato and tomato, although it also shows a marked partiality for tobacco seedlings, carrot, bean, lettuce, turnip, parsnip, cabbage, and cucumber. Flowering plants such as the chrysanthemum and the cineraria are also attacked, while cape weed is one of the favourite weed host plants. The destructive activities of this species are manifested mainly in the winter and spring months in this State, both the larvæ and the adults feeding on the selected host plants.

Life History and Habits.

The weevil (Plate 22; fig. 5) is one-third of an inch in length and is a greyish-brown beetle possessing two obliquely placed greyish-white patches on the back which form a distinct V-shaped mark. The eggs laid by the beetles in autumn and early winter hatch into legless larvæ which at first feed only on one surface of the foliage, generally the under surface. As they grow, however, irregularly shaped holes are eaten in the leaves (Plate 22; fig. 6). A feature of the infestation is that the larvæ (Plate 22; fig. 1) which shelter during the day characteristically feed at night, although a few may be seen feeding in sheltered spots on plants in the daytime. The full-grown larva is pale-green with a brown head and measures roughly one-third of an inch in length, an important feature being the presence on the head of short dotted darker lines which serve to distinguish this larva. The larva pupates in the soil in an earthen cell (Plate 22; fig. 2), wherein it transforms to a pale-green pupa (Plate 22; fig. 3), which eventually gives rise to a typical weevil possessing a long downwardly protruding snout. The beetle shelters in the soil by day and feeds voraciously by night on the foliage, generally leaving only the leaf stalks when it is at all numerous, although even these may be destroyed. The bulbs of carrots and turnips may also be attacked.

Control.

When infestation occurs on potatoes, spraying or dusting with arsenate of lead will be found effective against this pest. However, on other vegetables the arsenate of lead sprays or dusts cannot be directly applied for the control of this pest because most of its host plants would then carry undesirable spray residues on the parts to be used for food. Furthermore, in the case of tobacco seedlings many of

* *Listroderes costirostris* Schh.

the young plants would have so much foliage destroyed before the larvæ or beetles obtained a lethal dose of the arsenical that they would be severely weakened or would succumb to the attack; hence for the control of brown vegetable weevil the general practice is to employ baits consisting of the foliage of cape weed or of tops cut from tomatoes or other attractive plants that have passed the productive stage. These should be dipped in an arsenate of lead solution and placed between the rows of plants requiring protection or placed in the vicinity of seed-beds suffering from infestation. As in the case of cutworm baits, these succulent tops for the control of the brown vegetable weevil should be distributed in the late afternoon so that they will be fresh and attractive when the beetles and larvæ commence feeding at night. Should it be impossible to obtain the tops for this type of bait it is suggested that growers might use the bran bait employed for cutworm control, although it is not expected that the bran bait will give such good results against brown vegetable weevil. The destruction of weeds and rubbish in which the beetles may shelter during the summer months in the vicinity of cultivated areas or seed-beds should be productive of much good, the cleaning up being done before the beetles go into the inactive summer stage. Should heavy breeding be taking place on weed host plants in the vicinity of cultivated host plants, it is probably worth while to spray or dust the weed host plants with arsenate of lead, thereby destroying many brown vegetable weevils which would probably migrate to the cultivated plants at a later date. A further control measure that is worthy of consideration is the cultivation of infested land during the winter and early spring months when many of the brown vegetable weevils are in the soil in the prepupal or pupal stage at a depth of 1 or 2 inches below the surface. Such cultivation of infested land not then under profitable crops should lead to the destruction of many pupæ and prepupæ, thereby greatly reducing the number of beetles emerging in the spring months. The exact timing of the ploughing should be determined after an examination of the soil to ascertain the extent to which pupation has taken place, the operation being most effective when the maximum number of pupæ and prepupæ are present.

GREEN VEGETABLE BUG.*

The green vegetable bug is an introduced insect which has spread rapidly throughout eastern Australia and is most destructive in the summer months when it feeds freely on tomatoes and beans, both the fruit and foliage thereof being attacked. The skin of the attacked portion of the plant is pierced and the sap is extracted from the plant cells in the vicinity of the punctures. Attacked tomato fruit is mottled and unattractive in appearance, and when young bean pods are infested they become shrivelled and malformed (Plate 23). If the attack is confined to older pods, malformation does not occur, but the pods develop a mottled unhealthy appearance. When the foliage is infested it will generally be found that the results of the attack are most serious on the tender young growth. The general effect of heavy infestation is

* *Nezara viridula* L.

DESCRIPTION OF PLATE 22.

BROWN VEGETABLE WEEVIL.

Fig. 1.—Larva × 4½.
Fig. 2.—Pupa in earthen cell, natural size.
Fig. 3.—Pupa × 4½.
Fig. 4.—Adult, lateral view × 4½.
Fig. 5.—Adult, dorsal view × 4½.
Fig. 6.—Damaged lettuce plant, half natural size.
Fig. 7.—Damaged white turnip, half natural size.

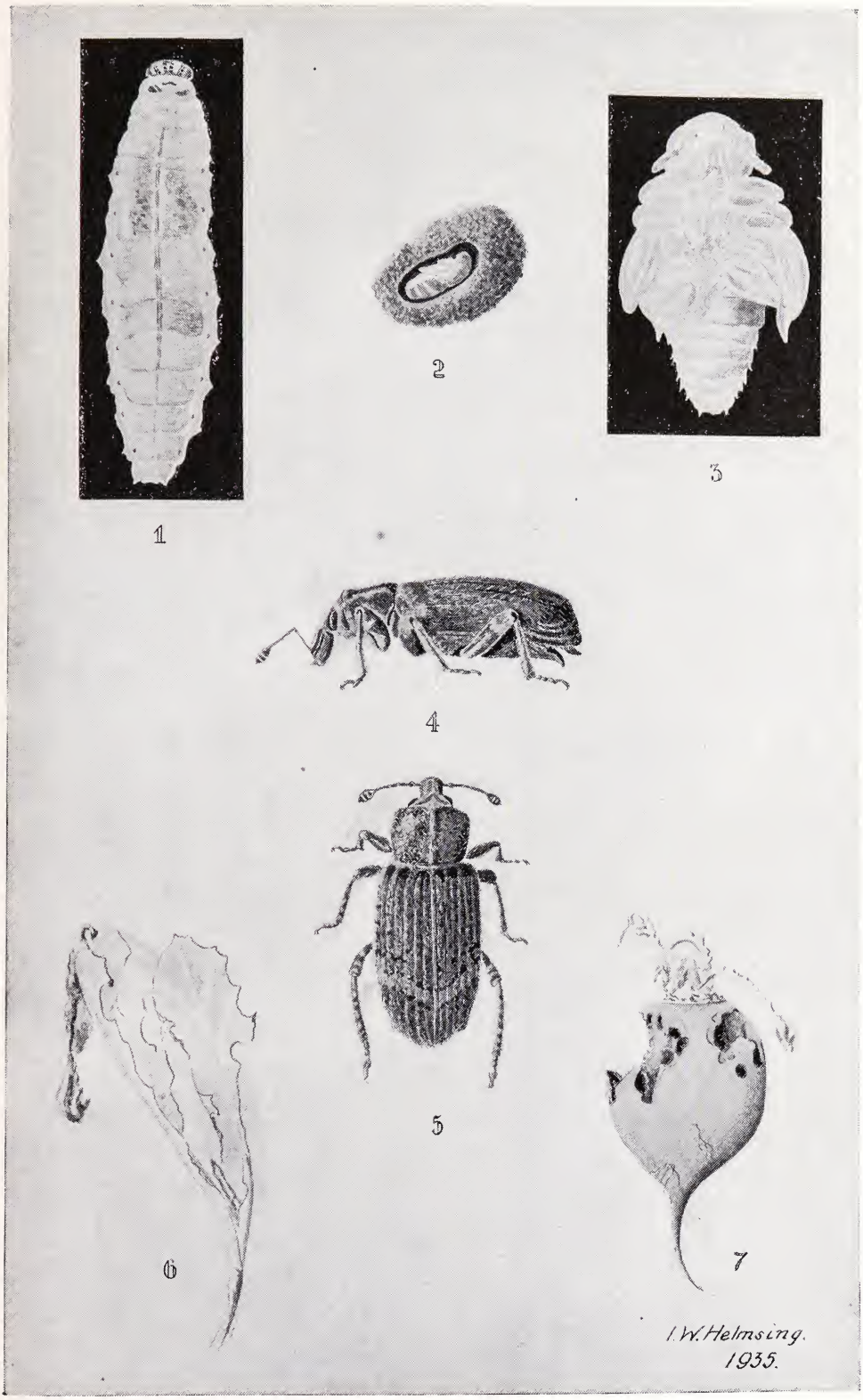

Plate 22.
BROWN VEGETABLE WEEVIL.

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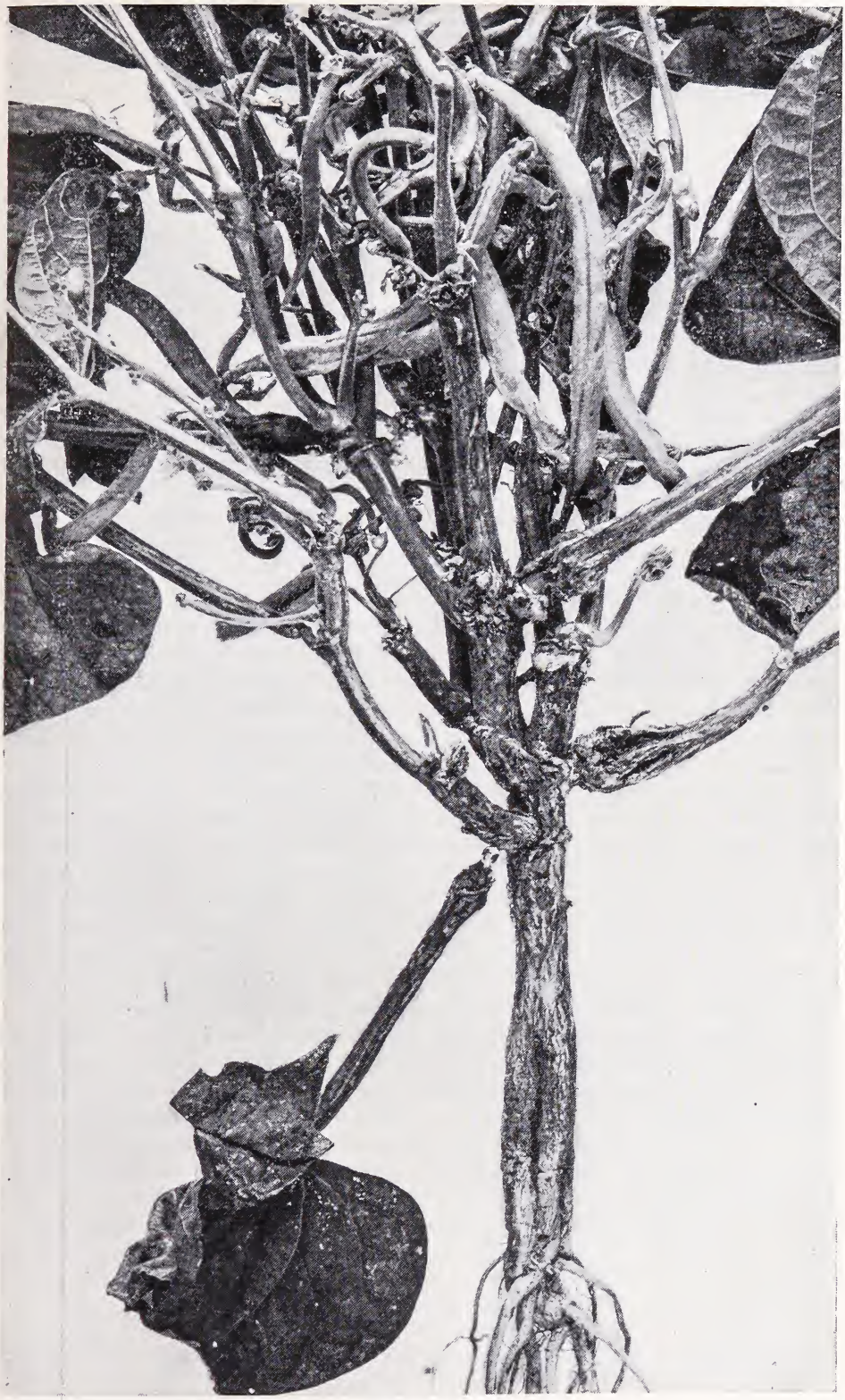

Plate 23.

INSECT-ATTACKED BEAN PLANT.—The bean plant illustrated shows damage to beans by the green vegetable bug. The stunted rather heavily branched vegetative growth, together with the swelling and splitting of the branch stalks and main stem is associated with bean-fly infestation.

a definite weakening of the plant and a marked reduction in the quantity and quality of the fruit produced. Potato, maize, melon, pumpkin, citrus, cape gooseberry, lucerne, and other plants may also be attacked in Queensland, but as already indicated the green vegetable bug is mainly a pest of beans and tomatoes.

Life History and Habits.

The full-grown bug is a light-green shield-shaped insect measuring half an inch in length by one-third of an inch in breadth. The life history of this species has not been worked out in detail in Queensland, but it would seem that marked activity does not commence until September, the cooler months being spent in a more or less inactive state. The cylindrical cup-shaped eggs are laid in clusters on infested plants, and after an incubation period of less than a week the very small bugs emerge. These bugs scatter over the plant a day or two after hatching, and passing through a series of moults they reach the adult stage several weeks later. The immature stages of this bug have black, green, yellow, and crimson in their varying colour schemes and are, of course, wingless. Several generations doubtless occur in Queensland each year, activity again slowing down at the approach of the late autumn months.

Control.

A considerable amount of time has been devoted to the testing of sprays for the control of this pest, but so far definite success has not been achieved. The difficulty is to obtain a spray sufficiently strong to kill the bugs without injuring the somewhat delicate foliage of most of their host plants. The nearest approach to success in Queensland has been obtained in preliminary experiments with a modified resin- caustic soda-fish oil spray with which a reasonable kill was obtained in the case of the immature stages of the bug. The formula for this modified spray is as follows:—10 lb. resin, 2 lb. caustic soda, 3 lb. herring oil, and 40 gallons of water. The spray is prepared in the same manner as the normal strength resin-caustic soda-fish oil spray as described on page 5, the only difference being in the variation in the quantities of caustic soda and herring oil. So far no injurious effects have followed the application of this spray on tomatoes, and growers who feel that a spray must be used can experiment with it, always remembering, of course, that it cannot be definitely recommended at present.

Failing the application of sprays, it is suggested that considerable benefit may be derived from the systematic collection and destruction of the egg clusters and bugs, more particularly in the spring months when the bug is on the move after having spent the winter in a somewhat inactive condition. The destruction of eggs and bugs early in the season should produce an appreciable reduction in numbers in the later summer generations. The egg clusters can be crushed by hand and the collection of the bugs is best undertaken in the early morning when they are sluggish, the bugs being collected in a suitable container, such as a kerosene tin containing a little water and kerosene. Clean cultivation with its attendant destruction of plant debris and rubbish in which the bugs may shelter and of unprofitable plants on which they may continue breeding is also of some value in dealing with this pest, the control of which is admittedly still on a somewhat unsatisfactory basis. The control of this insect on tomatoes, whether by spraying or systematic collection, is greatly aided if the plants are staked and pruned. Recumbent bushy plants are favoured by the insects and they also serve to shelter them from attempted control measures.

ONION THRIPS.*

A species of thrips is the only insect pest of importance likely to be encountered by onion-growers in this State, but when it is present in large numbers it may be responsible for very serious losses, the size and quality of the bulbs being adversely affected, and indeed the position may be so bad as to inhibit the production of a marketable crop. This very small insect lacerates the surface of the leaves and feeds on the sap of the injured tissues. Wherever this occurs a small white blotch or streak appears and these may be so numerous as to give the whole plant a silvery-white appearance. Heavily infested leaves wilt and a tip wither may develop, with the result that the whole plant assumes a markedly unhealthy appearance.

Life History and Habits.

The onion thrips is a very small delicate yellowish insect measuring one-twenty-fifth of an inch in length. The adult female possesses two pairs of narrow fringed wings, but the male, which is very rarely seen, and the immature stages of both sexes, are wingless. The female, which is somewhat darker than the male and the nymphs, lays her eggs on the onion plant, and at the end of an incubation period of about a week the minute wingless nymphs emerge and congregate at the bases of the newest leaves, occurring there in clusters of as many as forty or fifty individuals. However, when the onions are flowering the nymphs can be found on the flower stalks in considerable numbers, but they are otherwise confined to the bases of the young leaves. In spite of their light-yellow colour and their occurrence in clusters, the nymphs may be overlooked, except when present on the flower stalks, unless the leaves are held apart to expose the colonies situated at the bases of the youngest leaves. The adults occur on any aboveground portion of the plant, but are most frequently observed on the older leaves, and incidentally they are responsible for most of the damage. The nymphs moult to the prepupal stage and this and the following pupal stage are spent in the soil. Two to four weeks after the nymphs emerge from the eggs the adults appear and reinfest the plant, on which they move about actively.

Control.

Spraying with nicotine sulphate has long been recommended for the control of this pest, but local experience indicates that no appreciable kill of the thrips is obtained unless it is used at double the normal strength, thereby greatly adding to the cost of control. Derris spray at the normal strength does, however, give a kill of at least 80 per cent. of the adults on the treated plants. Owing to the nymphs' habit of congregating between the closely adpressed bases of the young leaves they cannot be effectively reached by sprays; hence the attack has to be concentrated on the adults. For the same reason the spray requires to be applied a second and possibly a third time to deal with the unkilled nymphs when they reach the adult stage and return to the onion plants from the soil. The spraying programme just outlined should also satisfactorily deal with probable reinfestation from sources outside the sprayed crop. The interval that elapses between the first and second spray applications has to be left to the discretion of the grower, who should keep a careful lookout for the reappearance of

* *Thrips tabaci* Lind.

adults. When these are present in appreciable numbers the second application should be made, and if the pest is in plague proportions, a total of three sprayings at intervals of a week will probably be necessary.

This species of thrips breeds on a large number of host plants, including certain weeds; hence clean cultivation will destroy some of its breeding grounds, and furthermore many of the prepupal and pupal thrips in the soil will be destroyed during cultivation operations.

LEAF-EATING LADYBIRD.*

Practically every farmer knows that many ladybirds are distinctly useful allies in combating certain pests, feeding as they do on such destructive insects as scale insects and aphids. A few are, however, plant feeders, and an Australian species, known as the leaf-eating ladybird, is a common pest of potato, tomato, pumpkin, watermelon, and cucumber. During severe outbreaks of this pest the foliage of attacked plants may be completely destroyed, and even the stems may suffer serious injury.

Life History and Habits.

The yellowish-brown oval-shaped beetle is about a quarter of an inch in length and each of its two wing covers is spotted with a number of conspicuous black marks, the number of spots on each varying from twelve to fourteen. The beetle lays its elongate-oval yellowish eggs in clusters on the foliage of its host plants, the number of the eggs in each cluster varying from thirteen to forty-five, the individual egg measuring one-sixteenth of an inch in length. The incubation period is about four days, at the end of which the extraordinary larvæ appear and feed for a period of three weeks on the lower surface of the foliage. The ladybird larva eats a narrow strip out of the underside of the leaf but leaves a thin layer of the upper surface intact (Plate 24; fig. 2). It then eats successive strips alongside the first, each being separated from its neighbour by a narrow unattacked ridge of tissue, thus producing a very characteristic effect. The full-grown larva measures one-third of an inch in length, yellow being the predominant colour on the upper surface of the body, which bears a large number of dark branched spines, the presence of these giving the larva a very hairy appearance. The larva pupates on the leaf or stalk of its host plant and at the end of a pupal period of four days the beetle emerges and feeds on both surfaces of the foliage, not infrequently eating right through the leaf tissue.

Control.

Spraying or dusting with arsenate of lead produces a heavy mortality in this species, and such an application may be made with safety at any time in the case of the potato. The possible injurious spray residue problem, however, arises in the other host plants mentioned if they happen to be carrying fruit when control is required. Arsenate of lead sprays and dusts are then usually undesirable, but it may be quite practicable to spray much of the foliage of watermelon and pumpkin vines without wetting the fruit with the arsenical spray. Such a restriction of spray to the foliage is, of course, quite impracticable in the case of the tomato and the cucumber when they commence bearing; hence it may frequently be impossible to safely use the only insecticide known to give satisfactory control of this species.

* *Epilachna* 28-*punctata* Fabr.

Plate 24.

INSECT-ATTACKED FRUIT AND FOLIAGE.—Fig. 1.—Banana attacked by the banana silvering thrips. Fig. 2.—Potato leaf attacked by the leaf-eating ladybird. Fig. 3.—Fig leaf attacked by fig beetle larvæ. All half-natural size.

Face page 94.

BEAN FLY.*

The bean fly is present all the year round in coastal Queensland, but during the winter months it is more or less inactive, and in the cooler weather a crop of beans may be produced reasonably free from attack. During the summer months, however, this is well-nigh impossible, and as no really satisfactory method of dealing with this pest has as yet been devised growers are urged not to attempt to grow beans in coastal areas during the summer months.

The very insignificant small black flies lay their eggs in the leaf tissue of the bean plants and the maggots hatching therefrom feed from the leaves into the stalks, and these become abnormally swollen, the swelling being frequently accompanied by splitting, the exposed tissue normally acquiring a rusty brown appearance (Plate 23). The creamy-coloured legless maggots grow rapidly and pupate in the tunnels in the infested stalks, the pupæ being formed in yellowish-brown cylindrical pupal cases, from which the flies emerge after a brief pupal period. This outline of the life history of the bean fly should serve to indicate the difficulty of the problem of control. Some relief may be obtained by pulling up and destroying useless heavily infested plants, and hilling up may assist the plants to produce new roots above the injured portions at the bases of the stalks. As already indicated, however, there is no really satisfactory method of dealing with this pest.

PUMPKIN BEETLE.†

The pumpkin beetle is an important insect enemy of pumpkin, watermelon, rockmelon, cucumber, and vegetable marrow, on the foliage and flowers of which it frequently feeds extensively. Young plants are often killed by the attack which may commence as soon as the seedlings appear above ground, while well established plants are seriously weakened by the feeding of the beetles on the foliage. This pest is very fond of the flowers of its host plants, and also displays a marked partiality for very small pumpkins, thereby producing a serious reduction in the crop. It occurs wherever its host plants are grown in this State.

Life History and Habits.

The orange-yellow pumpkin beetle measures a quarter of an inch in length, and is about twice as long as it is broad, there being two large black spots on each wing cover. The yellowish, elongate larvæ emerge from the eggs laid by this species after an incubation period of nine or ten days, and measure somewhat more than one-third of an inch in length when full grown, five or six weeks later. They feed at the bases of the stems and on the roots of their host plants, eventually pupating in the soil at a depth of several inches below the surface, the beetles emerging after the expiration of the usual pupal period.

Control.

Spraying with arsenate of lead will produce a reasonably good kill of the beetles of this species, but growers must use arsenicals with discretion, otherwise undesirable spray residues may be formed on the fruit of the vines; hence it is best to concentrate on control during the early stages of the growth of the vines, and to refrain from the use of arsenicals once the fruit has formed, except as indicated in the discussion on the control of the leaf-eating ladybird. Very young plants, even when sprayed, may be killed by the beetles before the latter have

* *Agromyza phaseoli* Coq.
† *Aulacophora hilaris* Bd.

consumed sufficient sprayed foliage to obtain a lethal dose; hence the seedlings are sometimes protected by covering each with gauze stretched over a suitable type of framework. The beetles are thus unable to gain access to the seedlings during a critical stage in their growth. Such a control measure can, however, be employed only on a small scale, and growers accordingly sometimes attempt to protect the seedlings by dusting them liberally with wood ashes or even road dust. In preliminary experimental work, it was found that the application of the modified resin-caustic soda-fish oil spray mentioned when discussing the green vegetable bug on page 90 gave a fair kill of the adult beetles. It was necessary, however, to jet the spray suddenly on to each cluster of beetles on the foliage to ensure thorough wetting before they were disturbed. No injury to foliage was observed, but it was preferable to apply the spray in the cooler hours of the day when the beetles were less active. This information is given more as a suggestion to those who desire to try an alternative method rather than as a definite recommendation.

SWEET POTATO WEEVIL.*

The beetles of this weevil attack the foliage, stalks, and tubers of the sweet potato, and their larvæ feed in the stems and tubers, the latter of which in cases of severe infestation may be rendered practically valueless as food for either man or beast. The tuber infestation is the most serious aspect of the attack of this pest, which is now widely distributed throughout Queensland.

Life History and Habits.

The sweet potato weevil (Plate 25; fig. 5) is a rather conspicuous, slender, ant-like beetle of a predominantly dark, metallic-blue colour, the legs and the middle portion of the body, however, being reddish-brown. It measures a quarter of an inch in length, and cannot readily be confused with any other species of insect likely to be found associated with sweet potatoes. It lays its very small, greyish-white, oval eggs (Plate 25; figs. 1 and 2) in cavities gouged out for the purpose by the female in the tuber or in the stem near ground level. The larvæ, on hatching after an incubation period of five or six days, burrow into the tuber or stem, and, as already indicated, the tubers may be riddled (Plate 25; figs. 6 and 7) and rendered valueless as a result of the presence of this insect. The larvæ (Plate 25; fig. 3) are stout, white, legless grubs, and measure about one-third of an inch in length when full grown, the head being pale-brown. The development of the larvæ is completed two or three weeks after hatching from the eggs, and they then pupate in oval cavities at the end of their burrows, pupation usually taking place close to the surface of the tuber. The pupæ (Plate 25; fig. 4), are of the usual weevil type, and after a pupal period of about one week the beetles emerge through irregularly-shaped holes in the surface of the tubers.

* *Cylas formicarius* Fabr.

DESCRIPTION OF PLATE 25.

SWEET POTATO WEEVIL.

Fig. 1.—Egg in cavity on tuber surface × 15.
Fig. 2.—Egg × 24.
Fig. 3.—Larva × 10.
Fig. 4.—Pupa × 10.
Fig. 5.—Adult × 10.
Figs. 6 and 7.—Infested tubers, half natural size.

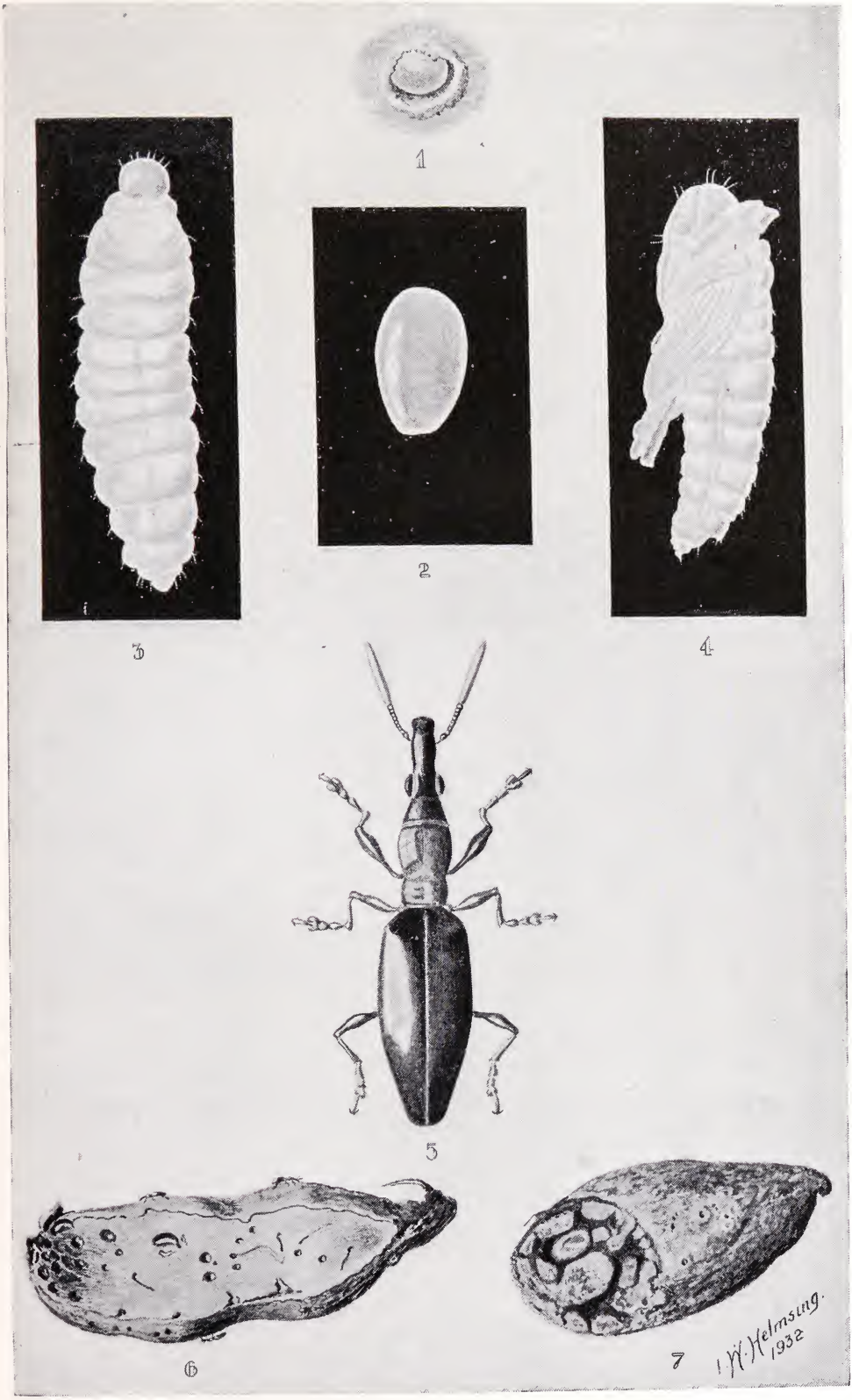

Plate 25.
SWEET POTATO WEEVIL.

Face page 96.

Control.

A thorough clean-up of the ground on which sweet potatoes have been grown is essential in the control of this pest, and all discarded infested tubers and vines should be collected and destroyed. Volunteer plants should also be destroyed, the aim being to eliminate as far as practicable all sweet potato material which may assist in carrying the pest over from one crop to another. Planting material required for the establishment of a new crop should be carefully examined, whatever is infested being rejected and destroyed. Furthermore, it is desirable to have the propagating bed from which this planting material is obtained situated as far as possible from the fields to be planted. Should the beetles be feeding freely on the foliage and stems some good may be accomplished by spraying with arsenate of lead while the plants are still young. Thorough cultivation of the land prior to planting and during the early stages of growth, to produce a fine tilth, will increase the vigour of the plants and will also ensure that the root tissues are exposed as little as possible to the attentions of the egg-laying females.

TOMATO MITE.*

The tomato mite attacks the stem, foliage, and fruit of the tomato, the foliage symptoms rather resembling the natural dying of older leaves. The infestation commences round the main stem which becomes rusty brown in colour and assumes a rather characteristic appearance as a result of the destruction of the surface hairs. The lower leaves curl up, become somewhat thickened and sometimes manifest slight silvering on the under surface. An indistinct brown discolouration appears, this becomes intensified and finally the leaves dry up. Younger leaves are affected in their turn and extensive premature defoliation ends the sequence, thus exposing the fruit to scalding. Blossom shedding may occur when infestation is severe and the attack on the fruit at first produces a dull, faint brown discolouration, the fruit eventually becoming extensively bronzed or blackened. The skin hardens and may crack, and the market value of the fruit is appreciably reduced. The mite responsible for this injury is an extremely small species which is hardly visible to the naked eye. It has a somewhat torpedo-shaped, light creamy-coloured, tapering body, and possesses legs which enable it to move at will, but somewhat slowly.

Control.

Spraying with lime sulphur at a strength of 1 in 100 (·21 polysulphide) should give reasonable control of the tomato mite, and colloidal sulphur has also been reported as being effective. Dusting with sulphur is a further alternative control measure. More than one application is necessary to obtain control of the pest, but the frequency of application will depend on climatic and other factors. Sufficient field experimental evidence, however, is not yet available to permit an expression of opinion regarding the actual number of applications required to control the tomato mite.

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* *Phyllocoptes* sp.

Chapter V.—GENERAL AND HOUSEHOLD PESTS.

The pests dealt with in this fifth chapter are root knot nematode, red spider, Rutherglen bug, red shouldered leaf beetle, termites or white ants, wireworms, false wireworm, meat ant, timber borers, rats and mice, slugs, woodlice or slaters, cockroaches, clothes moths, silverfish, house fly, and bed bug.

ROOT KNOT NEMATODE.*

Certain species of nematodes or eelworms attack living plant tissue; some are parasites of animals, while a few are predaceous on other nematodes. The species of agricultural importance in Queensland is the common root knot nematode, so called because of the characteristic swellings produced on the roots of infested plants. This species reaches its maximum abundance in light, sandy soils in the warmer portions of the State, heavy soils being much less favourable to its development, while soils that are either generally very wet or abnormally dry are usually lightly infested. Many important economic plants are susceptible to attack, but most grasses, maize, wheat, barley, broom millet, sorghum, peanut, velvet bean, and certain varieties of cowpea are either immune to attack or the infestation thereof is so slight as to be of no consequence. Heavy infestation in highly susceptible plants produces a marked dwarfing as a result of the disorganisation of the normal functions of the root system. Furthermore, such plants are decidedly less healthy in appearance than uninfested plants; they wilt readily during hot, dry weather, and generally the duration of their productive life is greatly curtailed.

Life History and Habits.

The female nematode (Plate 26; fig. 7) assumes a pear-shaped appearance when full grown, and then measures one-twenty-fifth of an inch in length, but the male nematode retains its worm-like appearance throughout life. The extremely minute eggs (Plate 26; fig. 5) of which as many as 500 may be laid by a single female, have a very tough shell which assists survival should adverse conditions prevail in the soil. The small thread-like nematodes (Plate 26; fig. 6) emerge from these eggs at the end of the usual incubation period, and move about the soil in search of suitable host plants. These having been located, the nematodes select young feeding roots and enter them, generally near the tips. Feeding proceeds within the root tissue, and as a reaction to the infestation of the roots the very characteristic galls are produced (Plate 26; figs. 2 and 3). Swollen, malformed areas occur throughout the root system of infested plants, and the swellings may either occur singly and only here and there on the roots, or, on the other hand, the infestation may be of such intensity as to give practically the whole root system a swollen appearance, some roots bearing a marked resemblance to a chain of beads. Infestation is not always confined to the root system, for, in the case of the potato, the tubers may be badly attacked, the surface thereof bearing a number of swellings (Plate 26; fig. 1) which impart a distinctly pimply appearance to the potatoes.

* *Heterodera marioni* (*Cornu*) Goodey.

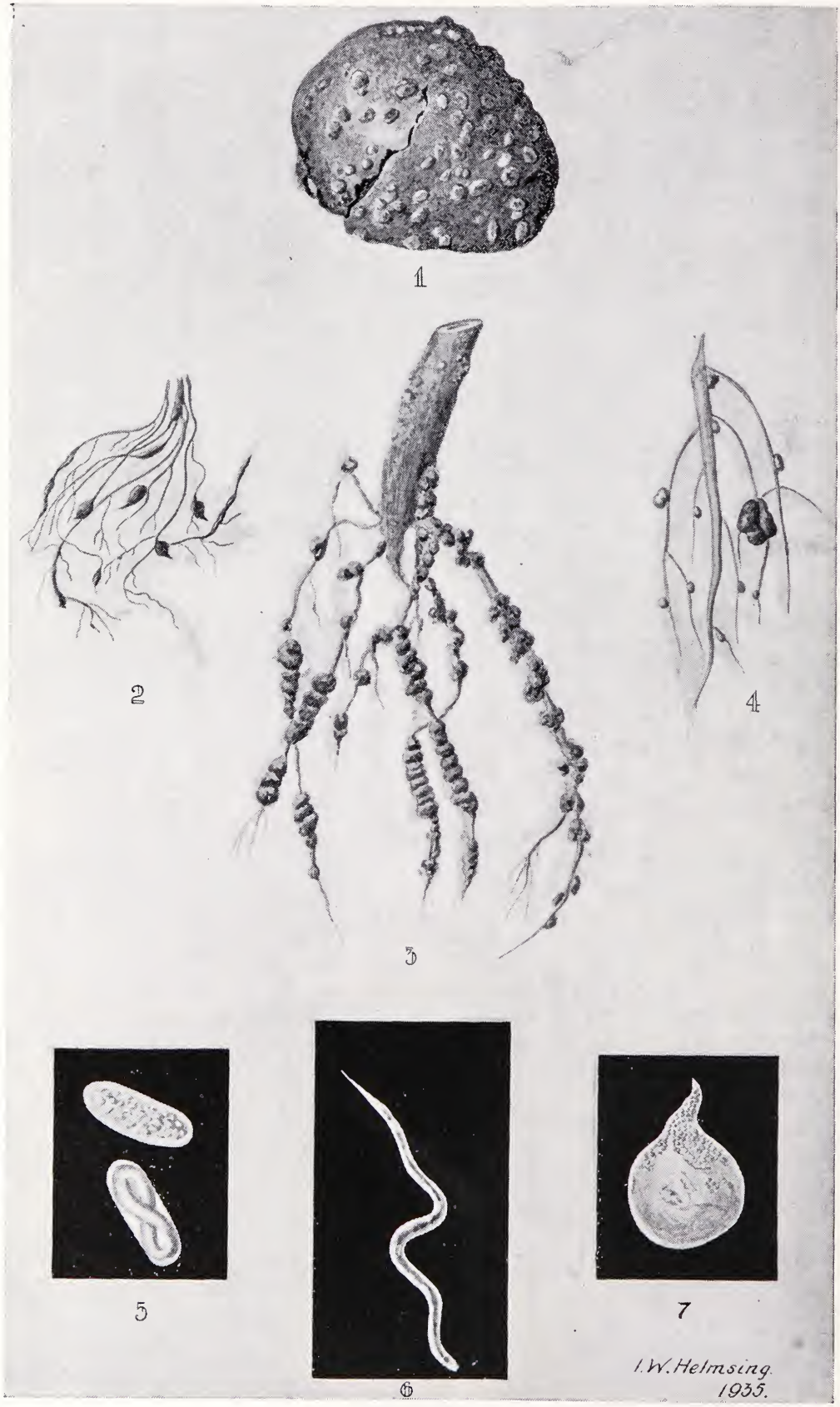

Plate 26.
ROOT KNOT NEMATODE.

Face page 99.

Other swellings may occur on the roots of plants belonging to the pea and bean family, but these are quite different in origin, being the beneficial bacterial nodules characteristic of that group of plants. They are usually spherical in shape and small or moderate in size (Plate 26; fig. 4), and can generally be easily detached from the sides of the roots on which they have developed. The nematode root galls cannot be so removed, and are, of course, wholly undesirable. Both bacterial nodules and nematode root galls may occur on the roots of members of the pea and bean family.

Control.

The control of the root knot nematode is an extremely difficult matter, because for the greater part of its life the nematode is securely entrenched within the tissue of its host plant. It does, of course, occur in the soil apart from the root tissue, and soil fumigation can dispose of large numbers of the temporarily free-living nematodes. So far, however, no system of soil fumigation has been used in this State which would be economically practicable as well as effective on an ordinary field scale.

Treatment of infested plants being quite out of the question, control should aim at maintaining the plants in as healthy a condition as possible, at reducing the nematode population in infested land, and at keeping uninfested country free from this serious pest. Thorough cultivation and heavy manuring frequently enable infested plants to produce quite a satisfactory crop, particularly if it is a rapidly maturing one such as tobacco. However, plants that have been infested in the seed-bed do not generally respond to such treatment, and such seedlings are better discarded and destroyed, transplanting being restricted to plants showing no outward sign of infestation. Seed-beds in districts known to be infested are best established, when practicable, on new ground, and a further seed-bed precaution sometimes adopted in infested areas is the steam sterilization of the soil prior to the sowing of the seed. When an infested crop has been harvested the uprooted crop residues should be destroyed by burning, where such a procedure can be adopted, for by doing so the nematode population available for the infestation of the succeeding crop should be appreciably reduced.

A further reduction may be achieved by rotating immune crops with susceptible crops, but the farmer must remember that infestation will inevitably recur, eradication being an impossibility. In cases where susceptible land is free from infestation every effort should be made to keep it so, and, if possible, any seedlings required for planting thereon should be grown on the property. If they have to be obtained elsewhere they should be carefully examined for the presence of the eelworms, and if infestation is present it is wiser not to use such seedlings on clean properties. Nematodes do not travel far in the soil, moving only a few feet each year, hence their rapid dissemination to

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DESCRIPTION OF PLATE 26.

Root Knot Nematode.

Fig. 1.—Nematode-infested potato tuber.
Fig. 2.—Nematode galls on strawberry roots.
Fig. 3.—Nematode galls on tomato roots.
Fig. 4—Bacterial nodules on lupin roots.
Fig. 5.—Nematode eggs × 150.
Fig. 6.—Larval nematode × 150.
Fig. 7.—Adult female nematode × 30.

Figs. 1 to 4 half natural size.

and in new areas is due to their being transported on implements, on the feet of workers and stock, in running water, and, of course, in seedlings, seed potatoes, or nursery stock. These modes of dissemination should be kept in mind when an effort is being made to maintain a clean property free from infestation.

RED SPIDER.*

The red spider is a species of mite often found on a wide range of economic and weed host plants, banana, bean, cotton, cucumber, deciduous fruit, grape vine, melon, papaw, pea, pumpkin, tomato, and strawberry being among the cultivated plants subject to severe infestation. This species must not be confused with the red mite, a common but relatively unimportant pest of deciduous fruit, which has already been discussed on page 28. One important distinguishing feature is the fact that the red spider is a web-spinning species, whereas the red mite does not possess the faculty of producing the fine silken threads so characteristic of a red spider outbreak. The species may also be separated in the laboratory by the relative lengths of the four pairs of legs in the adults, the front pair of legs in the red mite being much longer than the other pairs, whereas in the red spider such a disparity does not exist.

Life History and Habits.

The round, somewhat transparent eggs, which cannot be seen without the use of a hand lens, are laid among the silken threads on the under sides of the leaves of selected host plants, each adult female being capable of laying from sixty to seventy eggs at the rate of two to six a day during her adult life of two weeks. These eggs are laid irregularly on the infested foliage, and hatch after an incubation period of four or five days. The mites on hatching are six-legged, colourless, and rather transparent, but after feeding they acquire a greenish-yellow tinge. The female mites vary appreciably in colour, yellow, green, and brick-red individuals occurring, the otherwise uniform colour being broken by the presence of two dark spots, one on each side of the body, the occurrence of these spots being responsible for the designation of two-spotted mite which is sometimes applied to this species. The adult female possesses four pairs of legs, a short, rounded body, and mouth parts that enable it to suck the sap of the plant on which it is feeding, the length of the adult being about one-sixtieth of an inch. The adult male is somewhat smaller than the adult female, is less rounded, and is rather salmon-coloured, the darker spots being less conspicuous than in the female. During the height of summer the life cycle is completed in less than a fortnight.

As a result of the feeding of this mite, small pale spots appear on the infested foliage, which thereby acquires a mottled and unhealthy appearance. As the infestation becomes more intense the whole leaf acquires a light, unhealthy colour and withers, reddish-brown blotches not infrequently appearing, premature leaf fall and consequent weakening of the plant being the inevitable outcome of severe infestation. The under surface of infested leaves often has the appearance of having been dusted with a fine white powder, this impression being conveyed by the presence of large numbers of cast skins.

The red spider reaches its maximum abundance during warm, dry weather; heavy rain and a fall in temperature lead to a rapid decline in its numbers.

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* *Tetranychus telarius* L.

Control.

Spraying infested plants with lime sulphur at a strength appropriate to the plant to be treated and to the prevailing weather conditions produces satisfactory results against this pest. Lime sulphur sprays are unsuitable for some of the host plants of the red spider, and in such cases dusting with sulphur is sometimes employed. Reports on the results of sulphur dusting are, however, somewhat conflicting. The control of the pest should be undertaken at an early stage in the infestation, and whether spraying or dusting is employed every effort should be made to cover the under surface of the foliage, which is, of course, the seat of infestation. Furthermore, treatment should be carried out in such a manner as to ensure that no injurious residues occur on the marketed product. Spraying with a strong jet of water is sometimes recommended as suitable for relieving a few sturdy garden plants from red spider attack.

The fact that red spider breeds on quite a number of weeds suggests another line of control, namely, the elimination, in so far as it is practicable to so do, of whatever weeds are known to harbour the pest. Such weeds growing among or in the vicinity of the cultivated plants or on or near the ground to be planted are best destroyed by cultivation.

RUTHERGLEN BUG.*

The small insect known throughout Australia as the Rutherglen bug is always present in varying numbers in this State, but is normally of little practical importance. Every now and again, however, it suddenly increases to an extraordinary extent, but fortunately its numbers decline as quickly as they increase. During the course of such a brief outbreak, widespread and serious damage may be inflicted by the enormous numbers of bugs sucking the sap from the leaves, stalks, and fruits of the plants on which they are feeding. Attacked foliage wilts, and badly infested crops may be a complete failure. Young fruit will fall to the ground, and what does not fall is usually seriously blemished.

Life History and Habits.

The minute, creamy-white, elongate-oval eggs of this species are laid in bundles of two to seven on the flower heads of sow thistles, or singly in the down of cudweed, and on the seeds of blady grass. In slightly less than a week, the bugs emerge from the eggs and moult five times over a period of about three weeks, at the end of which time they become the winged adults. These are small, greyish-brown, rectangular-shaped bugs measuring one-eighth of an inch in length and possessing two pairs of silvery-grey wings.

Control.

The control of this pest constitutes a very difficult problem, largely owing to the fact that, during an epidemic, it exists in enormous numbers on weeds and other wild host plants on uncultivated land bordering the cultivation paddocks, and there is a constant migration from the uncultivated to the cultivated areas; hence, even if a good clean-up is obtained in the infested crop, the plants may be reinfested so quickly that a few days later the position may be almost as bad as it was before the application of the insecticide. Nicotine dusts and derris sprays have given some promise of success against this pest in so far as the mortality

* *Nysius vinitor* Berg.

of the bugs actually present at the time of the insecticidal application is concerned. As indicated, however, reinfestation may occur so rapidly as to counteract all the good that has been accomplished by spraying or dusting, and the Rutherglen bug must, therefore, be included in the list of insects the control of which requires much further investigation.

RED SHOULDERED LEAF BEETLE.*

The red shouldered leaf beetle may rapidly denude its host plants of foliage and flowers and severely injure their fruit. Fortunately, serious outbreaks occur only at infrequent intervals. Apple, avocado, banana, citrus, cotton, dahlia, fig, grape vine, loquat, maize, mango, mulberry, peach, pepper, plum, quince, rose, and wattle are recorded host plants. Any above ground portion of the host plant may suffer—*e.g.*, in cotton, the foliage, flowers, squares, bolls, and stem may all be attacked. The beetle feeds on either surface of the foliage which may be perforated or have only one or both surfaces eroded without perforation. The attacked leaves usually manifest both types of damage, and thus present a ragged perforated appearance (Plate 27; figs. 1 and 2). Extensive areas of the skin may be eaten (Plate 27; fig. 3), and the underlying pulp gouged out in fruits such as fig, apple, quince, and loquat.

Life History and Habits.

This squarish, sturdily built, pretty little beetle is about one-eighth of an inch broad, its length being equal to approximately twice its breadth. It is predominantly light-yellow in colour, but a light cherry-coloured band stretches across the base of the wing covers, and a pair of similarly coloured circular spots occurs on the back towards the end of the body. Little is known of the life history of this pest which may suddenly appear in enormous numbers, a single leaf of an infested plant not infrequently affording a harbourage for fifty or sixty beetles.

Control.

A flare prepared by securely wrapping old sacking or similar material round the end of a 7 or 8 feet pole can be profitably employed at night against this insect. The flare is dipped in kerosene, lighted, and carried between the trees or among the bushes known to be infested. The host plants are sharply jarred and a large proportion of the beetles thus disturbed will fly into the flare and be destroyed. The invasion is generally confined to a small area for a few days, and this control measure will be most successful if promptly employed before dispersal takes place throughout the orchard or farm. The sacking and kerosene should be renewed as required, the flare should be as bright as is consistent with the safety of the operator, and the jarring of the plants must be adequately attended to if satisfaction is to be obtained. Inspection before dusk to locate the heaviest concentrations of the beetles will enable flaring to be carried out where the beetle population is greatest.

A very satisfactory control of this pest can be obtained by the use of pyrethrum dust, applied preferably in the early morning when the beetles are somewhat sluggish. A fine uniformly distributed cloud of dust making contact with the whole beetle population is necessary; the beetles fall from the infested trees or plants shortly after dusting, and a second light dusting when they are on the ground increases the mortality rate. The cost of treatment can be reduced by mixing the pure pyrethrum with an equal weight of a cheap filler such as kaolin.

* *Monolepta rosea* Blkb.

Plate 27.

RED SHOULDERED LEAF BEETLE.—Fig. 1.—Attacked cotton leaf; Fig. 2.—Attacked fruiting branch of cotton plant; Fig. 3.—Attacked quince fruit and foliage.

TERMITES (WHITE ANTS).*

Termites or white ants are known to practically every Queenslander as extremely destructive enemies of timber (Plate 28), but many people are unaware of the fact that in some parts of the State termites are also responsible for considerable damage to living trees and other plants. Dwelling houses, farm buildings, wooden bridges, and fencing posts are all subject to attack, the total annual loss under these headings amounting to a very large sum.

Life History and Habits.

The best known termites are the mound-building species, their mounds (Plate 28) consisting of a maze of galleries with large underground extensions. Each of these mounds contains a queen mother housed in a large chamber situated at ground level in the centre of the mound. The queen may measure as much as an inch in length, and is rather a helpless, distended object, her sole function being to lay eggs which the workers carry away to other parts of the mound where they feed the subsequently emerging young termites. The workers also feed the queen, and they constitute the caste responsible for the damage to timber and plants. The members of the soldier caste are conspicuous among the mound inhabitants on account of their abnormally large heads and jaws, and, as their name indicates, their main function is to defend the other individuals in the termite colony. At certain seasons of the year winged male and female termites are produced, and these leave the mound, mate, lose their wings, and the surviving individuals choose suitable sites for the formation of new colonies.

Other species of termites are found in the soil under logs and stones, raised mounds not being formed in their case. A further group known as the dry wood termites, is characterised by the ability of the species constituting the group to successfully form and maintain colonies possessing no contact with the ground. Termites, other than those in the group just mentioned, retain contact with the subterranean nests by means of permanent communication tubes. The worker termites habitually forage far afield from the headquarters of the colony in search of food, and in doing so they form long galleries; open spaces, which have frequently to be traversed, are bridged by covered tracks of soil and wood debris.

Control.

The best procedure in dealing with possible infestation of a building by the ordinary mound-inhabiting termites is to take all practicable steps to prevent their gaining access to the structure. Any tree stumps, discarded timber, or other material likely to harbour termites should be removed from the land on which it is intended to build, and any colonies of termites on or near the building site should be destroyed. The stumps of the new building are best made from brick or concrete, and if wooden stumps are used they should be coated with creosote before being placed in position; all stumps must be capped with the usual square or circular galvanised-iron stump cap. The objective is the isolation of the main portion of the building by means of galvanised-iron caps from all timber or other materials in contact with the ground.

Should a building become infested, the first step in eradication is to determine the point at which the termites have gained access to the structure. Having done so, appropriate steps should be taken to once more secure the isolation of the building from the stumps or other

* *Termitidæ, Mastotermitidæ, Calotermitidæ,* and *Rhinotermitidæ.*

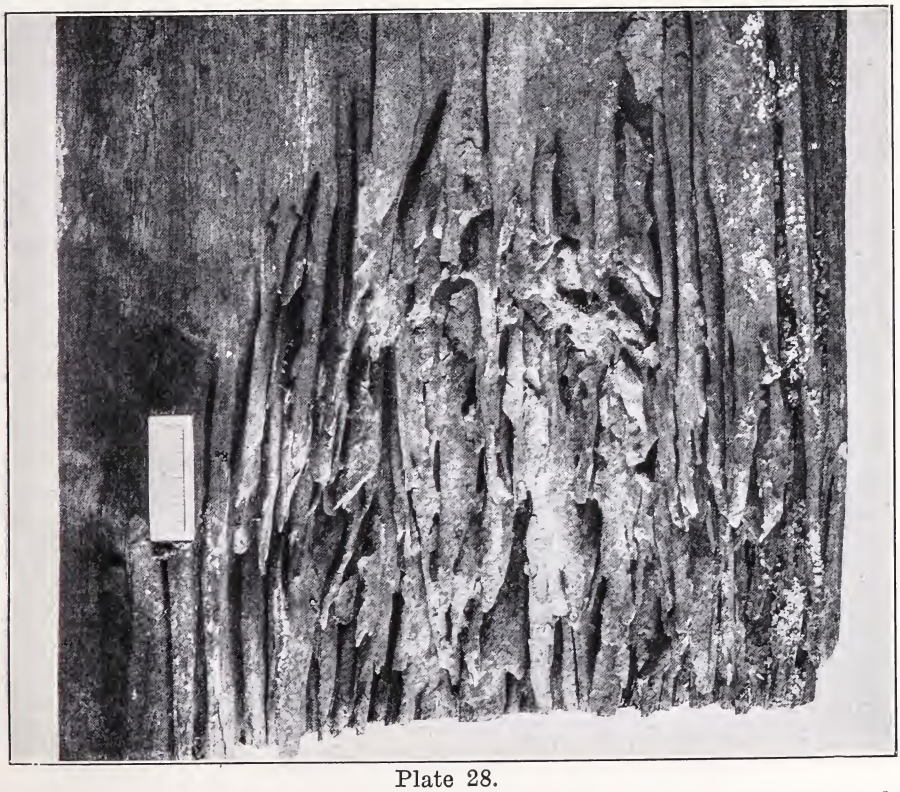

Plate 28.

TERMITES.—*Upper fig.*, Cross section of a termitarium exhibited at the Queensland Museum. *Lower fig.*, Timber damaged by termites.

portions of the structure in contact with the ground. This may necessitate the removal and replacement of infested wooden stumps and defective stump caps. Access may have been obtained by means of creepers growing on the walls, and if so these should be eliminated. The extent of the infestation within the building itself should then be ascertained, and all severely attacked timber should be replaced. As their connection with the soil has been severed, the termites in the lightly infested timber will soon die out.

Dry wood termites are not quite so easily located owing to the fact that their colonies are not connected by communication tubes with the ground. Fortunately, they are less common than the other species Timber heavily damaged by the dry wood termites should be replaced, while lightly infested wood may be treated by very carefully exposing some of the galleries by means of a sharp knife and gently blowing a small quantity of sodium fluosilicate into them. A small bulb blower is used for the purpose and the galleries are sealed as soon as the dust has been applied. The particles of this poison, which must be handled with care, will soon be distributed throughout the colony by the movement of the termites.

Fencing posts were mentioned as frequently being infested, and in their case the best procedure is treatment before being built into the fence. A recently introduced procedure is to place the posts in 40-gallon oil drums from which one end has, of course, been removed. A mixture of two parts of creosote and one part of crude or fuel oil by volume is then poured into the container until it is almost full. The drum and its inflammable contents are then carefully heated by an open fire, the temperature being brought up to 210° F. The heating period may last as long as four hours, its duration depending on the type of timber being treated. The posts and mixture in the drum are allowed to cool overnight before the posts are removed from the fluid or, alternatively, the hot fencing posts may be transferred to a drum containing cold creosote and crude or fuel oil and left therein for several hours at the same depth to which they were immersed in the hot mixture. Posts to be subjected to treatment should be seasoned before being immersed in the mixture.

Passing now to the control of infestation in living plants, the grower may adopt any one of several measures. Where a tree is infested a hole may be bored down to reach the tunnels of the termites and a small quantity of Paris green blown into it. Another control measure applicable where infestation is present in the root system or at the base of the tree below ground level is fumigation with paradichlorobenzene. For this purpose a trench 3 or 4 inches deep is dug round the base of the tree, at a distance of not less than 6 inches from the tree. The crystals of the fumigant are scattered in the trench, and the soil is replaced, care being taken that the crystals do not come in actual contact with exposed roots. It is rather difficult to give exact dosages for this treatment, but probably ½ oz. is a safe application for a weak young tree, 1 oz. for a stronger tree, and 2 oz. for vigorous well-grown trees. Another method of dealing with attack on living trees is to tie together two short pine boards, the inner faces of which have been smeared with an arsenical mixture, the boards then being buried in the infested soil. The mixture is prepared by adding 4½ lb. of molasses or treacle and 1¼ lb. of sugar to a solution of ¼ lb. of sodium arsenite dissolved in ½ pint of boiling water. The termites will feed on these baits, which should not be placed close to living roots.

WIREWORMS.*

Wireworms of some species or other occur as pests almost wherever agriculture is practised throughout the world, and are frequently highly destructive because of their partiality for feeding on seedlings and young plants which have either germinated in the field or been transplanted thereto from the seed-beds. Insect attack at such a stage of growth is particularly unfortunate, especially in the case of transplants, which naturally require favourable conditions to overcome the inevitable disturbance and injury to their root system involved in transplanting. Generally, however, well-established plants do not suffer seriously from the attacks of wireworms. These pests nibble at the roots of the young plant or at the base of the stalk, and they frequently enter the latter below ground level and tunnel up the heart of the young plant for an inch or two. At best the establishment of the seedlings is appreciably retarded, but only too frequently they succumb to the attack. Tobacco and tomato seedlings sometimes suffer severely from such infestation, but practically all cultivated plants may be attacked.

Life History and Habits.

The wireworms are somewhat flat, yellowish larvæ which are distinctly narrow in proportion to their length. According to species, the length varies from about 1 to 2 inches when full grown, the latter size being attained in certain species which feed on other soil-inhabiting insects instead of on plant tissue. The wireworms hatch from pearly-white, oval-shaped eggs laid in the soil, the larval stage in many cases extending to a period of two years. When full grown they pupate in the soil, and subsequently the wireworm beetles emerge from the pupæ. The beetles are dirty-grey or greyish-brown, flat, elongate insects, which possess the peculiar habit of "clicking" when laid on their backs, this faculty enabling them to turn over on to their feet once more.

Control.

Insecticidal control of wireworms has been the subject of many extensive experiments, but these have been productive of little progress towards a satisfactory solution of the problem. The wireworms are evidently distinctly resistant to poisons, and they seem to be more or less indifferent to the presence of repellents.

Some species occur in serious numbers only in poorly drained land; hence, if such a species is the cause of the trouble, every effort should be made to improve the drainage, thereby eliminating one of the chief factors predisposing to infestation. Other species, however, occur in soil in which the natural drainage is not defective, and in such a case some other mode of attack must be attempted. One suggestion is that when a particular field is known to be heavily infested with wireworms, more than the usual quantity of seed should be sown; if that is done it is probable that a sufficiently large proportion of the abnormally large number of seedlings will survive to give a reasonably good stand. When the field is planted up from seedling transplants a similar abnormally large planting may be profitably adopted in badly infested fields. Furthermore, the seedlings should be well hardened off before transplanting, and their growth in the field should be stimulated by thorough cultivation aiming at rapidly passing them through the critical stage following transplanting.

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* *Elateridæ.*

FALSE WIREWORM.*

Small, rather broadly built, greyish-black beetles, measuring one-third of an inch in length, frequently attack cotton, tobacco, and tomato plants at or just above ground level. They eat into the plant tissue, and as a result of their attack the infested plants wilt and are retarded in growth, while in many cases death ensues if the injury is severe. Their thin, tough, creamy-grey larvæ, which measure three-quarters of an inch when full grown, feed in a similar manner at or just below ground level, and as they bear a marked resemblance to true wireworms, they are generally referred to as false wireworms. Whole fields of young plants may be attacked, the percentage of losses being so high as to justify complete replanting. Usually, however, losses are not so extensive, but are frequently sufficiently severe to result in a very uneven stand, which has been obtained only after a considerable expenditure of time and money in replacing misses by the use of further transplants.

Control.

Fortunately, these pests feed on the bran bait generally employed for the control of cutworms, and growers are advised to protect their young plants by the use of that bait in cases where infestation threatens to lead to serious losses.

MEAT ANT.†

Meat ants are not infrequently a source of considerable annoyance, and it is often considered necessary to eliminate them. For that purpose the best procedure is to treat the large mound nests with carbon bisulphide, using ½ pint of the fumigant for a medium-sized nest. A small quantity of the carbon bisulphide is poured into each of the main entrances to the nest, which is then promptly covered with sacks. Three or four minutes later the sacks are removed and a light applied at several places, the light being attached at the end of a stick not less than 5 feet in length. The gas evolved by the carbon bisulphide then explodes and shatters the galleries of the nest, but the explosion will not be satisfactory if the light is applied too soon after pouring the liquid into the nest. Furthermore, it is important to note that five minutes should be allowed for the completion of the explosion before again covering the nest with the sacks. This recovering of the nest is for the purpose of retaining the fumes in the nest as long as is practicable in order to kill any ants surviving the explosion of the gas. Readers are reminded that this insecticide must be handled with care owing to its highly inflammable and explosive properties. Particular care must be exercised in applying the light after pouring the fumigant into the nest. This control measure is best applied in the late afternoon, at which time the ant population of the nest is at its peak.

TIMBER BORERS.‡

As the great majority of Queensland farmers live in wooden houses, and as timber enters very largely into the construction of the other farm buildings, it seems desirable to devote some attention to the borers which may become associated with the wooden portions of the buildings. Four beetles are commonly found in timber in this State, but two are of little practical importance, the third is somewhat destructive, while the fourth is a distinctly serious pest. There is a definite sequence in the time

* *Dasus macleayi* Blkb.

† *Iridomyrmex detectus* Sm.

‡ *Platypus omnivorus* Lea, *Prospheres aurantiopictus* L. and G., *Lyctus brunneus* Steph. and *Calymmaderus incisus* Lea.

at which infestation by the various species takes place, and the best procedure seems to be to commence with the log in the forest when it has just been felled by the timber-getter.

Newly-felled logs, whether softwood or hardwood, attract large numbers of very small cylindrical brown or reddish-brown beetles* measuring about one-eighth of an inch in length, and as a result of their attack straight tunnels of about the same diameter as that of small shot (Plate 29) appear in the boards sawn from the infested logs. These beetles are known as shot-hole borers, and it is characteristic of this group that its members cannot live in properly seasoned timber, being able to maintain their existence only in moist logs and unseasoned timber. This is due to the fact that the shot-hole beetles and their larvæ do not feed on the wood but subsist on a fungus which grows on the sap exuding from the walls of the tunnels. As the moisture content decreases with the seasoning of the timber, the fungus dies and the shot-hole borer larvæ succumb; hence these beetles cannot inflict any further damage in a wooden building, the extent of the injury being confined to the tunnels present when the building was erected. Such injury should in no way affect the stability of the structure.

A much larger insect known as the hoop-pine beetle† also lays its eggs in newly-felled pine logs, and the larvæ hatching from these eggs frequently complete their development in the sawn boards in which they form long tunnels. When full grown they pupate in the boards, and the black orange-spotted beetles, which measure two-thirds of an inch in length, emerge from the timber, often twelve or eighteen months after the erection of the building, the diameter of their flight holes being somewhat less than that of a lead pencil. Here again the adult will not lay its eggs in seasoned timber, so the infestation ceases and leaves only a few flight holes which can be puttied up and painted over. A common variety of this species is black in colour with no orange markings.

The third insect in the sequence is the powder-post beetle‡ a small flat reddish-brown insect about one-sixth of an inch in length. It lays its eggs in the sapwood, infestation (Plate 29) frequently commencing about eight or nine months after the timber has been sawn up or worked into a building in the form of stumps. Infestation, however, may occur at an earlier date. About a year and a-half after the building has been erected small heaps of wood debris as fine as powder make their appearance beneath the pin holes made by the powder-post beetle in infested timber. One pleasing feature of the attack, however, is the fact that in practically all timbers only the sapwood is infested, and moreover pine timbers are immune. Hence, although it will continue breeding in sapwood year after year and may cause unsightly holes in exposed timber within the house, structural safety should not be endangered by its presence, for the proportion of sapwood should be comparatively small in any faithfully constructed building.

The fourth insect is a small dark-brown beetle§ measuring one-twelfth of an inch in length, this species putting in an appearance only after the building has been erected a considerable number of years. It confines its attention to pine timbers, more particularly hoop pine, in which it attacks all portions of the timber which may be com-

* *Platypus omnivorus* Lea.
† *Prospheres aurantiopictus* L. and G.
‡ *Lyctus brunneus* Steph.
§ *Calymmaderus incisus* Lea.

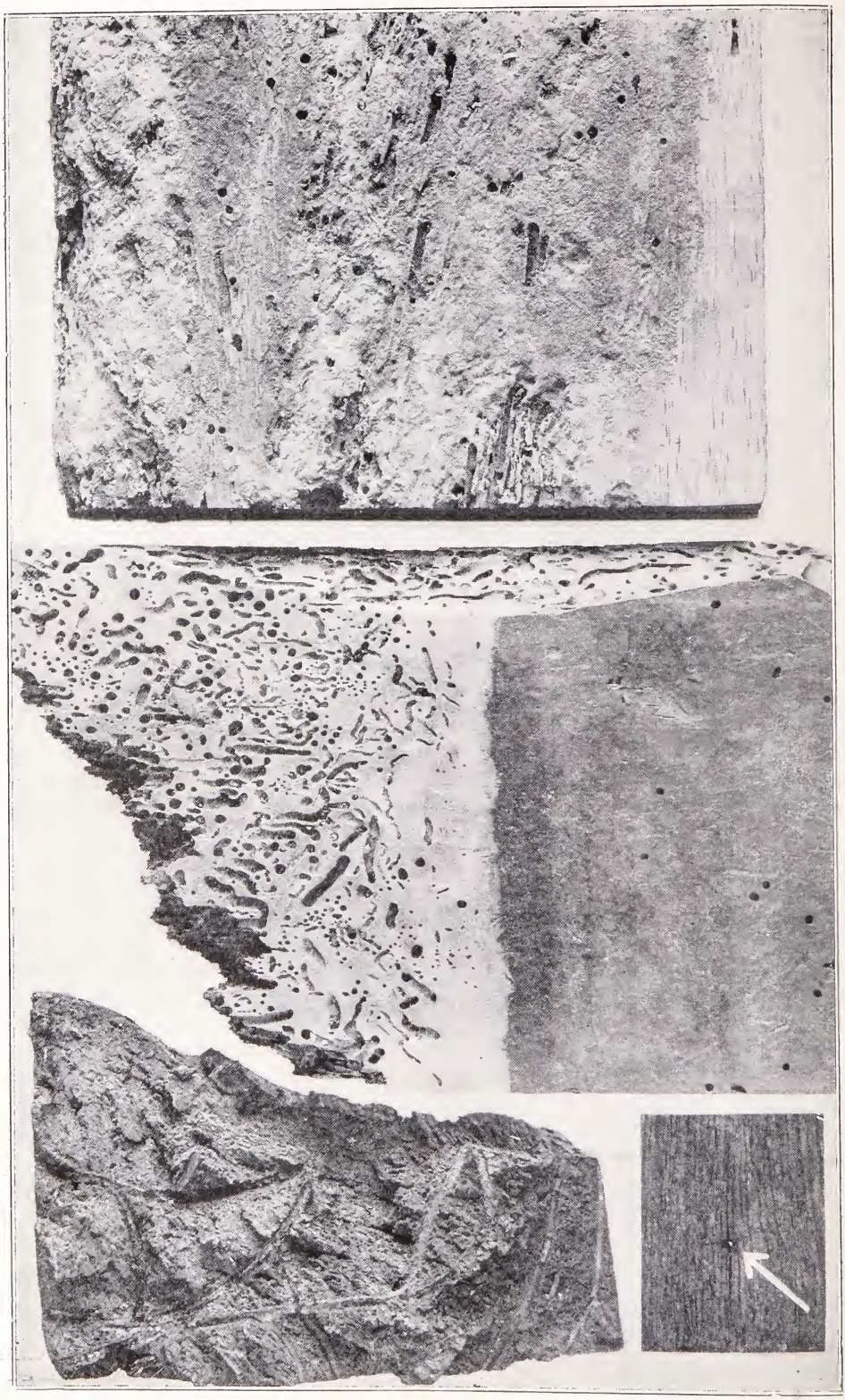

Plate 29.

TIMBER BORERS.—*Upper fig.*, Sapwood infestation by powder-post beetle. *Middle fig.*, Queensland pine beetle infestation. *Lower left fig.*, Shot-hole borer infestation. *Lower right fig.*, Outer surface of previous.

pletely honeycombed (Plate 29) as a result of its presence, infested flooring boards frequently crumbling under the weight of super-imposed furniture. This species is now commonly known as the Queensland pine beetle and is a dangerous species in a hoop-pine building in which it can go on breeding indefinitely once it obtains a footing.

Control.

From what has been said in the preceding paragraphs it is obvious that no measures need be taken against the shot-hole borer or the hoop-pine beetle. Some action, however, should be taken against the powder-post beetle, while control of the Queensland pine beetle is imperative. When house stumps are attacked by the powder-post beetle they should be painted with creosote or a mixture of creosote and kerosene in equal parts, care being taken to obtain a grade of creosote that will readily mix with the kerosene. This will kill a good proportion of the powder-post beetle population, but treatment may and probably will have to be repeated. The stumps assume a black appearance after treatment, but this is an improvement rather than otherwise, and where staining is of no consequence similar treatment can be given to other infested timbers. However, where staining is objectionable on exposed surfaces the creosote will have to be very much diluted, a dilution of one part of creosote to eight of kerosene sometimes being necessary in achieving the elimination of staining. Much trouble with powder-post beetle can, of course, be avoided by reducing to an absolute minimum the amount of sapwood used in hardwood timbers in constructional work.

When hoop pine is infested with the Queensland pine beetle the first step in control is to remove and burn heavily infested boards. The lightly infested boards may then be treated in the same manner as that described in the preceding paragraph, treatment being most effective when applied during spring, because at that time of the year many of the borers are close to the surface and are then most likely to be reached by the creosote or creosote and kerosene mixture. The treatment should be repeated after an interval of six weeks in order to deal with the borers which were not close to the surface when the earlier application was made A good proportion of these should then be within reach of the insecticide. Painting or varnishing timber confers some degree of protection against borer attack, particularly if both surfaces are treated.

RATS AND MICE.*

The ravages of rats and mice in foodstuffs and their breeding and feeding habits are sufficiently well known to warrant dispensing with a discussion of these aspects of the rodent problem. Consideration of the pests may therefore be confined to the presentation of the main facts relative to their control.

Firstly, emphasis must be laid on the desirability of rat-proofing certain classes of buildings by ensuring the elimination of all points at which the rats and mice can gain access. This involves a thorough examination of the buildings to locate such openings and their elimination by concrete, sheeting, wire gauze, or other suitable material. Such measures involving the rat-proofing of buildings are economically practicable in the case of large city produce and food warehouses and country storage depots, and the saving resulting from the prevention or reduction of losses arising therein from attack by rats and mice

* *Rattus* spp. and *Mus* sp.

justifies the expenditure involved. The rat-proofing of farm buildings is, however, quite a different proposition and cannot generally be accomplished at a cost that would be justifiable; hence consideration in such cases must be given to the destruction of rats and mice by trapping, poisoning, or fumigation.

Trapping of both rats and mice is of considerable value in rodent control, experience indicating that the simple wooden spring trap produces just as satisfactory or even better results than much more elaborate and correspondingly costly devices. Mice are readily caught if the traps are placed close to the spots frequented by them. The bait may consist of bread, apples, raisins, cheese, or almost any other foodstuff. Rats are not so easily trapped and success may not be achieved against them unless the traps are left unset but baited each day for a few days. They may then be once more rebaited, but this time they should be set, and the rats' suspicions having thus been allayed success may be achieved. Baits should, of course, be renewed each day, and in doing so, and in handling rat traps generally, the wearing of cotton gloves has been recommended.

Should trapping fail to exercise a reasonable degree of control of the infestation, poisoning will have to be resorted to in order to clean up the rodent population. Experience indicates that the most satisfactory poisons to employ for the control of rats and mice are red squill and barium carbonate. The former is now much in favour largely because it is the safest effective material to employ for such poisoning campaigns. The latter is also a favourite, chiefly because it is a somewhat inexpensive material; it is comparatively safe, and is quite effective. It should, however, be handled with discretion, and precautions must be taken to ensure that it does not contaminate human or domestic animals' food.

Red squill will produce good results in a campaign for the elimination of rats and mice, but its successful use is dependent on attention to certain details in the preparation and application of the baiting material. The first detail to which attention must be given is the provision of an adequate supply of bait to the rats and mice so that they may if practicable be eliminated by a single application of the material. The next point is that several types of bait should be laid in order to cater for the varying tastes of individual rats, and in this connection the reader's attention is directed to page 5, wherein he will find various formulæ for the preparation of red squill bait. A further important point is that as far as practicable no food other than the bait should be available to the rats and mice on the evening on which the bait is laid. The bait should be freshly prepared and applied in the late afternoon in small quantities about the size of a marble, particular attention being paid to the places where the rats and mice usually feed. The general practice is to wrap each small portion of bait in a loosely twisted piece of paper. Uneaten bait should be collected and destroyed.

Should some rats or mice survive the baiting procedure just outlined it will be necessary to repeat the treatment about three weeks later if a complete clean-up is desired. Baiting material is prepared according to the formulæ already referred to except that the red squill is omitted. The bait is laid several times at two-day intervals, uneaten bait being collected and destroyed each morning. This procedure allays the suspicions of the rats and mice, and, when these have

been overcome, red squill is once more included in the baiting mixture. It is well to remember that, although red squill is the safest poison to use for the control of rats and mice, it should not be handled carelessly. Most other animals, however, will either refuse to eat material containing red squill, or if they do so they will soon vomit the bait.

Barium carbonate bait, prepared according to the formula given on page 4, may also be employed in farm buildings with successful results. It is, however, somewhat poisonous to human beings and also to domestic animals, and for that reason preference should be given to red squill bait.

Fumigation is frequently employed for the control of rats and mice, but it cannot be recommended for rodent destruction on the farm.

SLUGS.*

The slimy, greyish-brown, small legless animals known as slugs feed by night on the leaves of a wide range of plants and are of particular importance in flower and vegetable gardens. Their eggs are laid in masses in the soil, under flower pots, behind edging-boards, or in other similar sheltered spots where damp conditions prevail. After an incubation period of about four weeks' duration the young slugs emerge, feed, grow, and eventually become adult.

Control.

Young seedlings may be protected by being surrounded by a ring of lime, renewed as required, but the lime should not be sprinkled on the seedlings themselves, otherwise severe scorching of the foliage may ensue. Masses of eggs encountered while gardening should be promptly destroyed, and much good can be accomplished by trapping the slugs. Small pieces of wood may be placed in damp spots frequented by the pests, and if these are examined in the morning any slugs congregated thereunder may be destroyed. The cutworm bran bait may also be employed against slugs.

WOODLICE (SLATERS).*

The slate-coloured, flat-bodied creatures known as woodlice or slaters are of but slight economic importance and are considered to feed for the most part on decaying vegetation. They do, however, occasionally attack the roots and foliage of small plants. Woodlice measure about half an inch in length, they possess a very markedly segmented body which bears a number of pairs of legs and are commonly found underneath stones and boards and in clumps of damp vegetation.

Control.

A thorough clean-up of weeds and rubbish in which woodlice shelter is the first step in their control. Small pieces of wood may then be placed in the damp localities favoured by them, and when they commence sheltering thereunder they may be killed mechanically or by poisoning, sodium fluoride being sprinkled beneath the pieces of wood. This insecticide should not come in contact with any vegetation other than weeds. Cutworm bran bait is also helpful against woodlice.

COCKROACHES.†

Cockroaches are highly objectionable in dwelling-houses, mainly because of the soiling of food, cooking utensils, and crockery that is

* Generic and specific identifications not available.

† *Blattidæ.*

invariably associated with their presence. A further undesirable feature of their feeding activities is the partiality they display for the binding of books which are all too frequently ruined if cockroach infestation becomes severe. The cockroach eggs are laid in brown, roughly rectangular, egg capsules in dark places, and the wingless young cockroaches emerging therefrom feed, moult several times, and eventually become winged adults.

Control.

Much good can be accomplished in cockroach destruction by the use of sodium fluoride, which is best scattered at the backs of book shelves, along beams and picture rails, and in any similar places frequented by the pests. The cockroaches in traversing these places pick up particles of the sodium fluoride, which they remove from their bodies by licking, thus eventually obtaining a lethal dose of the insecticide. It is well to remember that the cockroaches also breed under the house and the sodium fluoride should therefore be used in the laundry or any other enclosed space under the house that is likely to harbour the pests. If this is not done constant reinfestation will take place even if a satisfactory kill is obtained in the house itself. Sodium fluoride, like all other insecticides, should be used with care and should not be sprinkled in cupboards containing food or cooking utensils and crockery.

CLOTHES MOTHS.*

The larvæ of several species of moths habitually feed in clothes, and in a warm climate such as that of Queensland are capable of causing very serious injury to woollen garments not in constant use. They also attack upholstered furniture and carpets and a variety of articles of animal origin. The clothes moths, which are insignificant insects with a wing spread of about half an inch, lay their very small pearly-white eggs on the various materials chosen by the moths as suitable larval food, each moth being capable of laying as many as 150 eggs. On hatching, the larvæ commence feeding in the fabric on which the eggs were laid, and when full grown measure less than half an inch in length, the colour being white except for the brown head. The larvæ of some species spin silken cocoons which they drag about from one feeding place to another and within which they pupate when full grown. The typical brown pupæ are about one-sixth of an inch in length and eventually transform to the buff-coloured moths which are nocturnal in habits.

Control.

Woollen clothing should be well aired and brushed before being stored for any considerable period, particularly during the summer months. It should then be placed in a close-fitting drawer or trunk which should contain flake naphthalene or paradichlorobenzene, 1 lb. of the insecticide being used for each 10 cubic feet of the container. Should there be no close-fitting drawers or trunks available for this purpose, woollen articles such as blankets can be stored in tightly-tied cotton bags containing a liberal sprinkling of flake naphthalene or paradichlorobenzene.

Infestation of upholstered furniture and carpets is not of such frequent occurrence as is the case with stored woollen garments, the general use of vacuum cleaners being responsible for a good deal of

* *Tineidæ.*

control in the cities and country towns. Where such household labour-saving devices are not available it is suggested that a careful watch be kept on the upholstered furniture and carpets during the summer months, giving particular attention to the darker corners of the rooms and the portions of carpets covered by other furniture. Any clothes moth larvæ breeding in the furnishings should be killed and a liberal sprinkling of flake naphthalene in the infested portions should act as a deterrent to further attack.

SILVERFISH.*

Silverfish are small, delicate, wingless, silvery-grey insects responsible for a considerable amount of damage to clothes, wallpapers, and book bindings. Control can be obtained by using the silverfish bait discussed on page 4, particularly if its use is preceded by two applications of a pyrethrum spray at an interval of a week.

HOUSE FLY.†

The common house fly is sufficiently well known to readers to render a description of the adult stage (Plate 30; fig. 4) quite unnecessary. The other stages in its life cycle, however, are not so familiar to the average reader, hence some account of them seems desirable when discussing the life history preparatory to the consideration of control measures. The minute white elongate-oval eggs (Plate 30; fig. 1) are one-twentieth of an inch in length and are usually laid in closely-packed batches in fresh manure, decaying vegetation, &c., as many as 150 eggs being laid in a day by one fly, the total normal egg-laying capacity of the individual being about 500. The eggs hatch in less than twenty-four hours and the legless, white maggots (Plate 30; fig. 2) become full grown in about a week, when they measure half an inch in length and are then creamy-coloured objects tapering from the blunt posterior to the narrow pointed head. They feed in masses in the infested material on which their eggs were laid and then, when full grown, pupate preferably in loose moist soil at a depth of a few inches. The pupæ are formed within the old larval skins, which contract to form brown cylindrical-shaped pupal cases (Plate 30; fig. 3) measuring about a quarter of an inch in length. Four or five days later the familiar flies emerge from the pupæ and commence egg laying in about ten days.

The house fly is rightly regarded as a most undesirable insect, partly because of the irritation caused by it if present in considerable numbers and partly because of the fact that it is responsible for spreading quite a number of important diseases. The spread of disease is facilitated by the complicated structure of the mouth parts (Plate 30; fig. 5) and the hairy legs and sticky pads on the feet (Plate 30; fig. 6).

Control.

The first step in the control of house flies is the elimination, in so far as it is practicable to do so, of the breeding grounds of the pest. As already indicated manure is one of the favoured media for the propagation of the house fly, and if stable manure has to be stored for some time it should be closely packed in a rectilinear heap with well-smoothed sides. Fermentation with the accompanying generation of heat will proceed rapidly in such a heap of stable manure and house fly maggots will be able to survive only in its outer layers. These survivors, however, can be satisfactorily dealt with by spraying the outer layers with a solution of 1 lb. of borax in 6 gallons of water, using

* *Ctenolepisma longicaudata* Esch.

† *Musca domestica* L.

not more than 3 gallons to each 10 cubic feet of the infested manure. It is necessary to mention that not more than 15 tons of such borax-treated manure should be applied per acre as a fertilizer. On farms, the manure can also be handled by spreading it thinly in the sun so that it dries out rapidly and becomes unsuitable for the egg laying of the house fly. Such dried manure will, however, be a less valuable fertilizer than manure which has not been subjected to such treatment.

Where flies are numerous in spite of the precautions taken to reduce their breeding grounds all food, cooking utensils, and crockery should be screened and, where it is practicable to do so in districts subject to continuous heavy infestation, the dwelling-houses should be screened.

Finally the adult flies may be killed by the use of traps, swats, fly papers, and sprays, all of which are quite familiar to the reader. The formula of a cheap home-made fly spray will be found on page 9.

BED BUG.*

This loathsome insect is a most unwelcome guest in many buildings in the tropics and sub-tropics. It feeds freely on the blood of the people living in such infested dwellings and the bites set up intense irritation in many people and cause loss of sleep. Furthermore, the bed bug is under suspicion as a carrier of some very serious diseases, which is a further reason for endeavouring to rid dwellings of its unwelcome presence. The elongate whitish eggs are laid in cracks in the walls and furniture and in mattresses and spring beds, and the bugs remain hidden in these and similar positions during the day, emerging at night to feed on their victims. The young bugs are paler in colour than the reddish-brown adults and moult five times over a period of several months. The bed bugs, which are a quarter of an inch in length when in the adult stage, are able to live for months without food, and they also feed on mice and other animals; hence an infested house may remain infested even although it has been unoccupied for a considerable period. Fortunately, the adult bed bug is incapable of flight, as it possesses only rudimentary wings; hence infestations are usually localised although transference may occur in baggage and second-hand furniture.

Control.

Fumigation of infested buildings by the use of hydrocyanic acid gas is the most effective method of dealing with bed bugs, but such work should be carried out only by persons possessing experience in handling this very deadly fumigant. Should it be impracticable to arrange for such fumigation, much good can be accomplished by brushing kerosene, benzene, or one of the common fly or mosquito sprays into crevices suspected of sheltering the bugs or their eggs. This is admittedly a laborious task, as all crevices in infested rooms will require careful inspection and treatment if found to be harbouring the pest. Nevertheless, it is the only alternative to fumigation and must be persevered with over a considerable period to ensure elimination of the last traces of the bed bugs. When benzene is used in bed bug control the building must be well aired before lighting any fires or lamps.

* *Cimex lectularius* L.

DESCRIPTION OF PLATE 30.

HOUSE FLY.

Fig. 1.—Eggs × 15.
Fig. 2.—Larva × 5.
Fig. 3.—Pupal case × 5.
Fig. 4.—Adult × 5.
Fig. 5.—Proboscis × 34.
Fig. 6.—Foot showing claws and pads × 34.

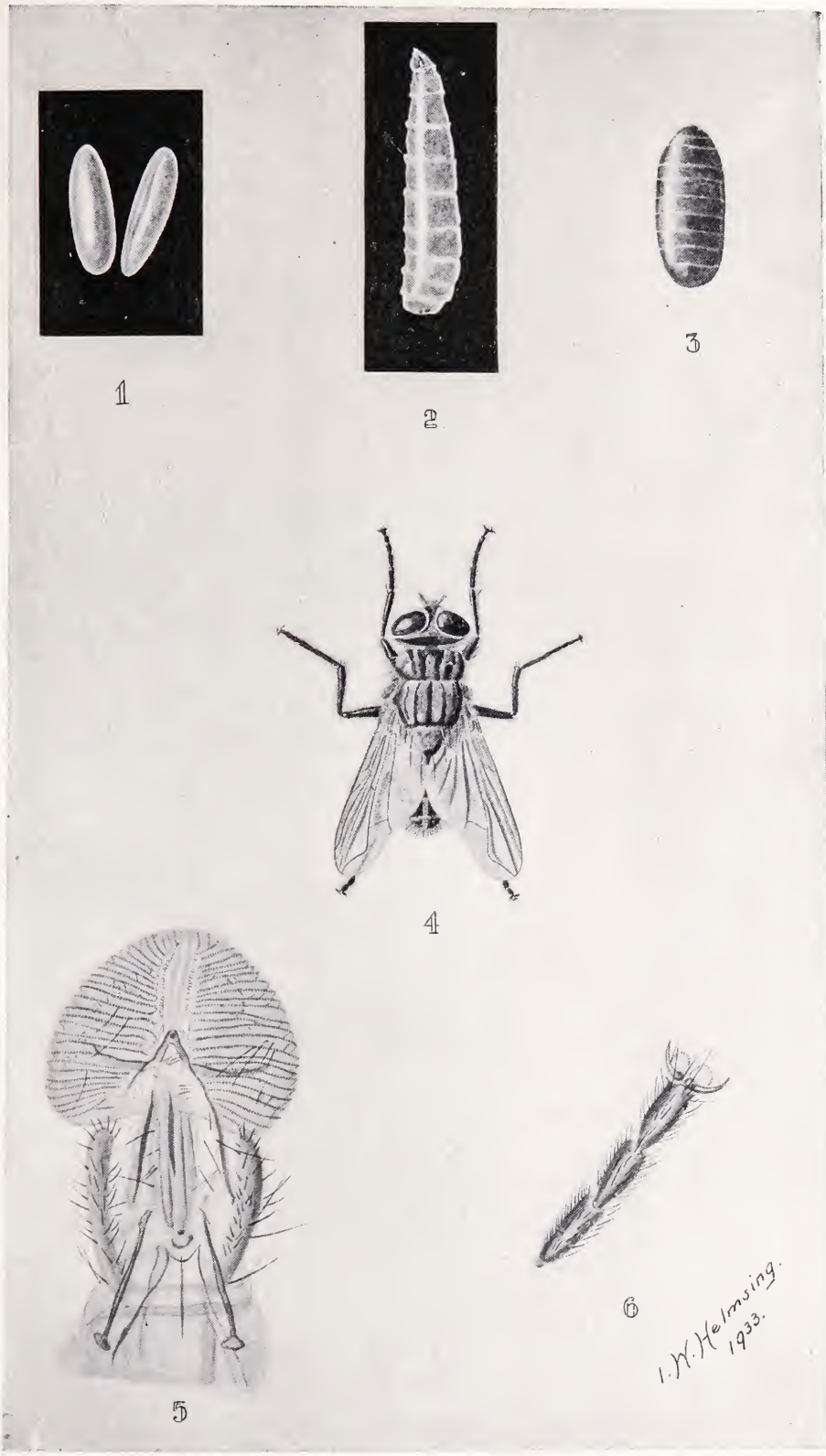

Plate 30.
HOUSE FLY.

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* The figures in heavy black type denote illustrations; the others refer to the text.